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PROGRAMMATIC AND RESEARCH STRATEGY

FOR THE

CONTROL OF MAJOR ENDEMIC DISEASES IN AFRICA

— April 4-7, 1977 —

[illegible]

525 23rd Street, N.W.

Washington, D.C.

[illegible] by [illegible] AFRICAN-AMERICAN [illegible]
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# INTRODUCTION

The International Conference on Programmatic and Research Strategy for the Control of Major Endemic Diseases in Africa was held from April 4-7, 1977 at the Pan American Health Organization Headquarters in Washington, D. C. The Conference was convened by the African-American Scholars Council in cooperation with the National Medical Association and with the support of the Agency for International Development. The primary purpose of the Conference was to assist AID in developing strategies for:

1) research on operational problems of programs for the control of selected tropical diseases which critically impede social and economic development in Africa; and

2) programmatic assistance to African governments in planning and implementation of endemic disease control programs in Africa.

An additional purpose of the Conference would be to share the findings with national governments and international agencies for use as they deem appropriate.

## -- Background --

The major endemic diseases in Africa cause widespread human suffering and impose serious constraints on socio-economic development. Onchocerciasis, schistosomiasis and trypanosomiasis are among the most serious, based on incidence, severity and spread associated with agricultural and water development projects. Control of these diseases merits special attention at this time when many African countries are initiating rural development projects and are seeking ways to extend health services to a larger portion of their rural populations.

Historically, the application of existing technology to the control of endemic diseases in Africa has had variable results. In the judgement of many experienced tropical disease control experts deficiencies in programming and operations are as critical obstacles to success as are the limitations in current technology. These obstacles include deficiencies in health infrastructure, shortage of skilled manpower, management and financing of programs, and inadequate planning.

Resources --human and financial-- for control of endemic diseases in Africa are very limited so there is a need to find the most efficient way to apply the control methods now available, as well as those being developed through research. Eradication and comprehensive programs for the most part are not feasible in Africa at this time. Consequently, there is a need to concentrate control operations in priority problem areas and to utilize cost-effective methods and delivery systems. Also, there is a need to explore new mechanisms for funding and implementing control in high risk situations such as irrigation projects. Control of these diseases is a very complex problem. It includes a great range of activities and a variety of objectives; it affects several development sectors and involves numerous national, international and local organizations. A technically sound overall strategy is essential to the effective control of these diseases in Africa and to the provision of the required programmatic and research support.

An important initial step is to define as accurately as possible the problems of implementing control programs for each of these diseases in Africa and to suggest solutions offered by current technology and programming approaches. Solutions might include research on operations of control programs and on adaptation of control measures to African needs and institutions. It should be pointed out that this research should compliment not duplicate the research projected under the WHO Special Program for Research and Training in Tropical Diseases (TDR), which is launching its activities in Africa. The aim of the WHO/TDR program is "to develop, through research, more effective control methods for tropical diseases, with the corollary objective of strengthening bio-medical research in the tropical countries."

The chief task of those attending this working conference was to define as accurately as possible the problems of implementing control programs for onchocerciasis, schistosomiasis and trypanosomiasis in Africa and to identify alternative solutions offered by technology and programming approaches. The findings are to be helpful to AID in developing its strategy of assistance on the control of endemic diseases in Africa.

The conference was structured to allow maximum time for working groups. Three working groups were organized, each focussing on one of the endemic diseases under study and each composed of about 15 international experts on the subject. Participants were furnished with background papers, references and discussion guides. These materials were designed to guide them in discussing and resolving the key issues on which their expertise was needed. The topics covered included the magnitude of the problem, major problems in applying existing control/eradication technology under existing conditions in Africa, manpower and training needs, and research needs. Findings and recommendations of the working groups were shared at the closing plenary session.

The findings and recommendations of the conference are documented in this report. They will serve as the basis for planning practical strategies for the control of these diseases in Africa.

## OPENING STATEMENT

-- presented by MR. HAVEN NORTH --
Deputy Assistant Administrator
Bureau for Africa
U.S. Agency for International Development

On behalf of the Agency for International Development and the Africa Bureau, let me join in extending special thanks to the African-American Scholars Council. Dr. Hilliard and, of course, our own Dr. Cross are the key figures in helping to bring this group together. We are deeply appreciative of your coming and taking time from your other endeavors to share with us the profound knowledge that we know you have on the particular diseases that we are trying to consider in this conference.

I think that what we hope to accomplish from this conference is for you to get across to us and the administrators of assistance programs, information that you have been trying to tell us for a good many years. This has recently come more forcibly to our attention. In our own programs, we have begun to realize that the consequences of the health constraints and the impact of health on development is more critical than perhaps those of us in the administrative and the policy side of the program have realized. This was brought very forcibly to our attention in the Africa Bureau of AID in the last several months. We have discovered that we had to stop for a period to design some of the major programs concerned with food production. We had moved ahead with these projects with a great deal of enthusiasm looking forward to what they could accomplish, and then found in the detailed examination of these projects that we really could not go ahead with them until we dealt with, understood, and had a solution or an approach to the health aspect of these problems and projects. The concern that came to our attention is, for example, in food production projects where we must address the health constraints. Otherwise, we will not be successful in our efforts. My colleagues in the health field have hammered this point at us for a long time and we have been sensitive to it. But now with our greater sensitivity to the environmental concerns of our programs, and perhaps even greater sensitivity to the impact on people, we have had to retreat and take another look at our program. We have had to ascertain whether, in fact, it is an effective program that can achieve the objectives without addressing the health problems. Certainly the practical problem of moving ahead with our program is being affected by health constraints. These problems need to be dealt with quickly and effectively, if we are going to move ahead in any major development activities. But beyond this, I think there is a further theme that has evolved in the last several years in our assistance programs. This theme is that much more of our attention should be focused on the poorer population. As you all know too well, in the past, emphasis has been on growth, per capita GNP, GNP percentage rate increases and other kinds of massive economic concerns. As a consequence we have failed to give consideration to the importance of equity and particularly to the effects of our programs and their contribution to the well-being of poor people and the poorest population in the country. Recognition of this in the last several years has again reinforced the importance of looking at health problems, and at the impact of our programs as they affect the health of the people. It is critical that we determine how we can accelerate our assistance in the health field to make a more immediate contribution to the health of the people, particularly those in the rural areas. These two factors have brought into sharp focus the importance of having a conference such as this. We are looking to you for guidance -- education -- on how to tackle some of the major health problems we all face jointly in Africa.

I guess there are really two questions that we on the programming side and the administrative side would ask. Firstly, what are the practical research programs that one can undertake to address the operating problems of getting health services, particularly to control the diseases we are discussing at this conference, into effective operation? Secondly, how can we more effectively address these kinds of diseases, and what kind of research should we undertake in the operational sense? I'm speaking very practically. I know there is a great deal of research on the basic problems of the diseases, but in the operational sense, what kind of research should we undertake <u>now</u> in order to address these problems? The only other issue that we would raise, and of course, you can point out other prospectives on this, is the impression that many of us have that there is a great deal of technology that we are now using. There is a great deal that we know to address the problems of these diseases that we are not putting to work. You can help us to put this knowledge on the table into a programmatic design in order for us to use it to implement effective activities now. We are looking to you for very practical recommendations, both on how operational research, and on how the technology we now have can be put to work efficiently, adequately and effectively to meet the immediate problems of the people affected by these diseases.

Finally, I should only comment that I think we look upon this conference as a milestone in the consideration of ways in which we can address the basic health problems in Africa as far as the AID Assistance Program is concerned. We look to you for guidance. From your guidance we can then readjust and realign our programs so they can be more effectively consolidated with the efforts of our colleagues in the developing countries. We do plan and are hoping to expand substantially our assistance in the public health field, but we need your direction on how that can best be achieved. I hope that you do not let the grandeur of the study and the formality of the introductions keep you from rolling up your sleeves and getting down into some hard practical debates and discussions and give us some practical charge in order that we may join together in an effective program addressing these problems that are so fundamental to the development in Africa.

Thank you very much.

# SCHISTOSOMIASIS, ONCHOCERCIASIS AND TRYPANOSOMIASIS IN AFRICA and the WHO Special Programme for Research and Training in Tropical Diseases

**DR. JACQUES HAMON**
**Director, Division of Vector Biology and Control**
**World Health Organization**
**Geneva, Switzerland**

Mister Chairman, to begin with I want to thank the African-American Scholars Council, the U.S. National Medical Association and the U.S. Agency for International Development for their kind invitation to come to Washington to attend the present meeting. I am very glad to be among so many colleagues and friends to consider how to tackle some of the major endemic diseases which critically impede socio-economic development in Africa. I hope that this conference will be a great success and its conclusions will be highly relevant for all those cooperating in the development of this continent.

To public health specialists it seems only too obvious that diseases, sickness, suffering and premature death, with all the associated and preceding disabilities, are causes for considerable economic losses everywhere in the world, and especially in tropical areas where many endemic diseases of considerable severity exist over and above all those occurring also in temperate countries. Unfortunately, the actual importance of health as a factor of development is not always as obvious to economists and policy makers at the national and international level, and health must compete for limited resources with all other sectors: agriculture, exploitation of natural resources, clergy, transportation, education, development of general infrastructure, defense, etc. Furthermore, major questions arise within the health sector itself as to which type of health activities should have priority, and which are the priority diseases, as the means available at the government level and at the level of the communities concerned are never large enough to cope with all the felt needs. These problems are especially acute in Africa where many factors have contributed to a rather slow development of very large parts of this continent.

Amongst the health sector it is traditional to blame the economists and policy makers for their relative lack of consideration for health to which they pay only too often lip service. We should consider whether the public health specialists are really as much to blame for this situation, as it is also true that in many instances health improves as a consequence of economic development. This can be attributed to better education, housing, food, clothing, accessibility to facilities of all sorts, and, last but not least, availability of larger financial resources. Consequently, it is also up to public health officers to present their case in a language and in a form understandable to economic planners, and to carry out all the required analysis to develop a sound health policy which would constitute both an effective service to people and a major contribution to development while requesting only a reasonable share of the national resources.

In tropical Africa, before the Second World War, the network of hospitals and dispensaries was rather limited and the main emphasis was placed on the prevention and control of a few acutely killing diseases, such as yellow fever, smallpox and sleeping sickness. The periodic outbreaks of these diseases were wiping out populations and preventing any sort of development. Actually, these diseases were often the threat used by medical authorities, at the national or local level, to increase their share of the allocation of resources. During the past 30 years, public health objectives have become more ambitious: the network of hospitals and dispensaries is slowly spreading to rural areas, and the development of public health manpower has been considerably speeded up, although continuing to be far below what could be considered an absolute minimum. However, it is only very recently that efforts have been made to analyze the health situation of each country and define priorities giving more importance to the many people of rural communities scattered all over the country, than to the inhabitants of urban areas. This is not only based on altruistic considerations and the will to develop a better economic order, but also to the mere fact that in most African countries a very large proportion of the gross national product comes from the rural population; thus any factor hindering rural productivity and goodwill also hinders the country's economic development. Furthermore, dramatic examples have shown that economic development projects, especially when involving the management of water resources, can contribute to the spreading of certain parasitic diseases in rural areas and thus not produce the anticipated economic output.

This new trend has nevertheless some limitations at present: in Africa unemployment is often widespread and sick people unable to work, either temporarily or permanently, are easily replaced for all minor routine tasks. Sickness does not thus always appear clearly as one of the key factors hindering natural productivity. Medical facilities continuing to be scarce and out of reach of most of the population, sick people are left to their own resources and those of their family, and the direct cost of sickness to the community is extremely difficult to determine as long as no medical treatment is given and cases are scattered in time and space. Furthermore, medical practitioners and nurses working in tropical Africa, where polyparasitism is almost the rule and most patients harbour simultaneously a number of pathogens and parasites, are often at a loss to ascertain with accuracy the main causes of sickness and death, due to the lack of laboratory facilities and time. The net result is a gross disagreement between public health specialists about the main causes of morbidity and mortality per age group which can only unfavourably impress economists and decision makers. I will always, myself, remember a technical conference on major communicable diseases in West Africa where, after listening for a week to high level experts by merely adding up the sectoral causes of mortality authoritatively produced by each expert during the week I reached the conclusion that the infant mortality rate was far above 100%. The situation is not much better when prevalence of the diseases is considered, and many of the figures produced at the continent level, and sometimes the country level, constitute more guesswork than the result of thorough field studies enabling sound extrapolations to be made. Serious consideration might be given to the solution of this problem - what are the actual causes of morbidity and mortality in rural areas of tropical Africa and how, in a given epidemiological landscape, parasite and pathogen prevalence data can be translated in terms of sickness, disability, etc. and economic losses for the rural communities concerned. A few local or sectorial investigations have been carried out, but more are needed and the improvement of health statistics is one of the prerequisites for the development of a sound public health policy based on facts and not guesses.

Pending a better understanding of the health situation, it is nevertheless possible to categorize the diseases according to their main characteristics and group them by technical and operational affinities. One can, for example, consider the following categories, the list being far from complete. Cardiovascular and oncogenic diseases, which are steadily developing and are usually not fundamentally different from those encountered in temperate countries; diseases which can be prevented or minimized by environmental sanitation, health education, etc. and for which effective chemotherapy does exist. This is the case of diarrheal diseases, nutritional deficiencies, sexually-transmitted diseases, etc; viral and bacterial diseases which can be prevented or minimized by immunization procedures and which mostly require vaccine production and the solution of logistic problems to keep a high level of immunization amongst populations at risk. This is the case, in particular, in yellow fever, smallpox, tuberculosis, measles, pertussis, poliomyelitis, etc. WHO is organizing an Expanded Programme of Immunization, worldwide to cope with them; these diseases for which prevention is not yet possible on a collective basis, but where effective drugs exist to cure the sick and could be made available to all communities concerned. Sometimes drugs have their limitations or might not rest effectively for long, constituting borderline cases requiring additional research, such as in the case of leprosy, malaria and lymphatic filariasis. There is also a group of diseases against which the presently available preventative and curative tools are far from satisfactory, and much research and development is needed to eliminate them as major public health problems. This is especially the case of schistosomiasis, onchocerciasis and trypanosomiasis.

For public health administrators, over and above political considerations, the above analysis may have some usefulness and the definition of a sound strategy could be based on a few criteria, such as:

- which diseases are the most important in terms of morbidity and mortality in each of the endemiological landscapes of the country?

- against which of these important diseases do prevention and control tools exist, the use of which is within the reach of the country's resources?

- how can the resources allocated to public health at the various administrative levels be utilized to maximize their socio-economic impact?

A last important criteria might be the possibility of maintaining the situation stable, or even to improve it further, when disease morbidity and mortality have been decreased to a very low level. Too often the maintenance of results over long periods is more difficult to ensure than the initial control of the disease during the attack phase of control operations.

This problem is very difficult to solve, as already indicated, and requires certainly a pragmatic approach at the national level to take into account local constraints and the social relevance of the various alternatives. We may have to consider it, however, in general terms, as it would be futile to propose sectorial approaches and strategies which would neglect other diseases than those dealt with by the present conference.

For those in charge of medical research for tropical countries, the above analysis defines clearly a few targets requiring additional investigations: leprosy, malaria, filariasis in general, schistosomiasis and trypanosomiasis, and these are the diseases which constitute the main targets of the WHO Special Programme for Research and Training in Tropical Diseases which is under implementation.

The purpose of the WHO Special Programme is to improve the control of these selected tropical diseases in affected countries with two interdependent objectives, namely: to develop improved tools for the control of these diseases, and to strengthen the relevant biomedical research capability of tropical countries. The Special Programme is based on an analysis of the problems of disease control carried out in consultation with numerous experts from all over the world and its main aspects and goals have been presented to interested authorities and the scientific community in documents dealing with:

- the selected diseases, current problems of their control and potential research approaches (immunotherapy, chemotherapy, vector control, and when appropriate operational research for a better use of the tools already available, etc.);

- general aspects concerning simultaneously several diseases (epidemiology, biomedical research, vector control with special emphasis on biological control, etc.);

- institution strengthening and manpower development for medical research;

- socio-economic aspects, which should be studied with the aim of establishing better links between economists, planners, and public health specialists;

- programme management aspects.

These documents are available to all those interested and it does not seem useful to deal with all these aspects at great length. I would prefer to answer specific questions, if any, and send the documents to those wishing to receive them. It must only be stressed at this stage that the WHO Special Programme will be kept very flexible and be planned, implemented, and continuously managed in close cooperation with the world scientific community while taking fully into account the relevance of the various approaches for the endemic countries concerned.

The three groups of diseases selected for the present conference belong to those selected for the WHO Special Programme and thus the findings and recommendations of the conference working groups will constitute additional useful information for the WHO Special Programme. At this point it should be drawn to the attention of the participants that the background documentation contained in the conference folders is not entirely up to date. The Special Programme sectorial reports on filariasis and trypanosomiasis have been distributed, but that on schistosomiasis has not. The report of WHO Expert Committee on the Epidemiology of Onchocerciasis published in 1976 has not been made available. Furthermore, the African trypanosomiasis situation was reviewed in late 1976 by a joint WHO-FAO Expert Committee, but the final report is not yet available. Fortunately some of the participants have the up-to-date documentation with them and will probably use it during the discussions.

It does not seem appropriate to expand much in this presentation in order to describe in detail the problems raised by the prevention and control of schistosomiasis, onchocerciasis and trypanosomiasis as there are people here much more qualified than myself to describe them. I will thus limit my comments to a few points.

Schistosomiasis, a chronic helminthic disease, is probably by far the most prevalent of these three diseases considered by the conference. In Africa, where it is almost exclusively a human disease, most of the rural population and even part of the urban population is at risk and the number of infected people might be close to 100 million. The most widespread is the vesical schistosomiasis, due to S. haematobium. The most serious is the intestinal schistosomiasis, due to S. mansoni, which has often a spotty distribution. The less widespread is that due to S. intercalatium which is mostly localized in some parts of the equatorial zone of the African continent. Until recently drugs available for the treatment of schistosomiasis had great limitations, due to their incomplete effectiveness and frequent side effects. This situation is improving and some new drugs under advanced field screening will probably completely change this picture and enable the carrying out of larger scale operations. However, the treatment of parasitized people is of limited epidemiological significance if cured people are reinfected soon afterwards, which implies the need to act also against the snails constituting the intermediate hosts of the disease. For similar reasons the use of molluscicides has side effects on non-target organisms, including fish, and more studies are definitely required on that aspect. While immunization appears as a remote possibility, there is an obvious need to develop an improved control strategy which, within the framework of the local epidemiology of schistosomiasis would aim to limit its prevalence and the wormload in infected people by a sound association of chemotherapy, molluscicides, decrease of man-infected water contact, and decreased contamination of the water by Schistosoma eggs. One of the main characteristics of schistosomiasis is its tendency to spread with any economic development involving irrigation, impoundments, man-made lakes, etc. and one of the greatest priorities might be to prevent this spread of disease.

Onchocerciasis is a chronic filarial disease said to affect more than 200 million people in tropical Africa, but this is only an order of magnitude as in most endemic countries outside the Volta River Basin area there are very few solid data. Even in the Volta River Basin area one country reported some years ago only a few cases of onchocerciasis in the Annual Report of the Health Department, while the number of infected people in that country exceeds probably half a million. This indicates the degree of accuracy of the statistical data available at the continent level. Onchocerciasis, although mostly known because of the severe ocular lesions, culminating in the blindness that it causes in certain endemic areas, is also a systemic disease affecting the skin and many other organs, but the socio-economic significance of its non-ocular aspects is imperfectly known. The drugs currently available for onchocerciasis control either have very limited effectiveness or give very serious side effects, or both, and recent chemotherapeutical investigations have not yet screened many promising alternatives, although some improvements are anticipated. There is no immunization and prospects of developing it do not seem bright. Control operations are presently mostly based on vector control, but they require large resources as the blackfly vectors breed in streams and rivers, have a short reproduction cycle and sometimes a considerable flight range, reaching or exceeding 100 kilometers. In the absence of any effective and safe chemotherapy, control programmes should interrupt transmission in about 20 years - the anticipated maximum life span of the adult parasite - to be fully effective. This is what has been planned for the Onchocerciasis Control Programme in the Volta River Basin area, but securing such long-term resources is not easy nowadays and it is imperative to find short cuts to control this disease. The main economic importance of onchocerciasis resides in the fact that in hyperendemic areas of the savanna zone it prevents the settlement and economic development of fertile valleys, inducing people to live far away from the waters where the vectors breed.

Trypanosomiasis is an acute protozoal disease which has a very low prevalence in human populations, and thus differs considerably from schistosomiasis and onchocerciasis. But it can be a relatively rapidly spreading disease, prone to cause dramatic outbreaks. Furthermore, in areas where it is caused by *Trypanosoma b. rhodesiense* it is a zoonosis, with natural reservoirs constituted by wild game and cattle. The evidence of the existence of an animal reservoir of epidemiological significance is not as great where the disease is caused by *T. b. gambiense*, although experimentally the parasite can be maintained for long periods on certain domestic animals. Immunization is not available and the search for immunizing methods progresses very slowly, due to the great antigenic variability of these parasites. Chemotherapy is available and chemoprophylaxis was extensively used in the past, but all drugs in current use are prone to cause serious side effects in some of the treated people, and mortality from the treatment is not uncommon. Any relaxation of the efforts made to control the disease usually results in localized (or even generalized) outbreaks and the main economic cost of human trypanosomiasis is not so much that associated with the disease itself as the cost of the surveillance system needed to keep the disease absent, or at very low incidence. Vector control, when successful, constitutes an absolute answer to sleeping sickness. It is relatively easy to eradicate human trypanosomiasis vectors from their limited habitats in the dry savanna belt of West Africa where the transmission is due to riverine tsetse flies, but it becomes extremely difficult to eliminate the vectors from the humid savanna zone where their breeding places are widespread, and it is out of the question to eradicate them from the forest belt. The situation is even more difficult with *T. b. rhodesiense* areas where the vectors are savannah tsetse flies widespread over enormous areas. From an economic viewpoint human *Trypanosoma* and their vectors do not constitute a suitable target for those developing drugs and pesticides, because the market is too limited. Fortunately similar problems occur with animal trypanosomiasis, the presence of which considerably hinders cattle husbandry and meat production in most tsetse fly-haunted areas of Africa. The size of the veterinary market is much larger, and the problem of human and animal trypanosomiasis should be considered as a whole, with specific facets for each of its components. It must be stressed that cattle trypanosomiasis is not exclusively transmitted by tsetse flies but that the worst epizootiological situations occur where *Glossina* are present.

Thus, the general characteristics of the three groups of diseases selected for this conference is their close relationship with water resources and agricultural development, as well as the lack of appropriate tools which might facilitate the implementation of control operations when and where required in the poor endemic countries of tropical Africa.

Please note that the views expressed here are mine and may not necessarily represent those of the World Health Organization.

I apologize for having taken so much of your time, but I hope that these explanations might assist in placing the problems ahead of us in their proper perspective.

# SCHISTOSOMIASIS-RESEARCH TO CONTROL*

PETER JORDAN

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In three isolated valleys on the West Indian island of St. Lucia a comparative evaluation was made of snail control, chemotherapy, and provision of water supplies in the control of Schistosoma mansoni transmission. In Cul-de-Sac Valley, 4 years of area control of Biomphalaria glabrata by using 25% emulsifiable concentrate reduced the incidence of new S. mansoni infection in children up to 10 years old from 22% (1970-71) to 4% (1974-75). Prevalence among a cohort of 9 to 14-year-olds was reduced from 34% to 23% intensity of infection fell, and the infection rate in sentinel snails decreased from 3.9% to 1.1%. In five villages on the south side of Riche Fond Valley water was provided to individual households and three simple swimming pools and five laundry units were built. With education, there was a 90% reduction in observed contact of the community with rivers and streams. All parameters of S. mansoni infection fell -- incidence from 31% to 12%, prevalence among a > 1- to 14-year-old cohort from 47%, and the sentinel snail infection rate from 0.5% to 0.2%. In a nearby comparison area with a communal water supply S. mansoni prevalence increased. In Marquis Valley hycanthone at a dose of 2.5 mg/kg body weight was offered to all found infected with S. mansoni at annual surveys in 1973 and 1974; those found infected in 1975 were given oxaminiquine. After two chemotherapy campaigns incidence fell from 18.8% to 4.1%; no infections were found in sentinel or wild snails after the first treatment campaign. After 2 years of control, chemotherapy reduced incidence from 18.8% to 4% snail control; from 22% to 9.8%; and water supplies from 22.7% to 11.3%. Annual costs per capita in the first 2 years were $1.10 (chemotherapy), $3.70 (snail control), and $4.00 (water supplies). Chemotherapy was the cheapest and most rapidly effective method of achieving transmission control and additionally provided disease control. A disadvantage, not shared by snail control, is that it requires population cooperation and a stable community. Cooperation, but not necessarily a stable community, is required for water supplies (which provide other social and medical benefits) to be effective.

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Presented at the Symposium, Frontiers in Clinical Tropical Medicine, at the annual meeting of the American Society of Tropical Medicine and Hygiene in Philadelphia, Pennsylvania on 5 November 1976. This meeting was held jointly with the Royal Society of Tropical Medicine and Hygiene. Partial support for the symposium was provided by the Upjohn and Janssen Companies.

In 1965 the Rockefeller Foundation and the Government of St. Lucia started a program to investigate methods to control the transmission of *Schistosoma mansoni* on the island. Financial help to St. Lucia was provided by the British government.

At the time, schistosomiasis control was in its infancy. In Japan[1] and Venezuela[2] successful public health control had been in operation for some years but with all possible control tools employed: measures against the snail through habitat modification and the use of molluscides, chemotherapy, sanitation, provision of water supplies, and education. These schemes resulted in prevalence of infection falling significantly; however, as they were "public health" schemes, not oriented toward research, the relative importance of the component parts of the programs in achieving control was unknown.

In the early and mid-1960s snail control was generally considered to offer the most effective and rapid means of reducing transmission,[8] although this opinion was based as much on theoretical considerations and the failure of other methods as on demonstrated success of snail control. However, environmental measures against the snail proved effective in reducing transmission in the Phillippines,[4] and by 1965 copper sulphate and sodium pentachlorophenate were being replaced by Bayluscide. The latter was used successfully, and for the first time on a large scale, in the Egypt 49 scheme between 1962 and 1965[3]. Concurrently, Frescon was undergoing evaluation.

This emphasis on snail control reflected in some degree prevailing lack of drugs suitable for community treatment. But with the advent in 1964 of ambilhar--given orally and, by comparison with other drugs, over a short period of time (5 days) l/m it became just possible to envisage chemotherapy on a community basis. Prospects for community treatment grew distinctly brighter with the subsequent appearance of hycanthone and oxaminiquine, both effective in a single dose.

In 1966 first reports were received from South Africa of transmission being reduced with the use of water supplies,[5] simple swimming facilities, and physical barriers to prevent access to infective water. A similar scheme in Brazil, where latrines were also installed, showed some evidence of success.

Thus in 1965, when St. Lucia's Research and Control Department came into existence, there was still little information about what could or could not be achieved in the way of schistosomiasis control using the available tools, or about the advantages and disadvantages of these different approaches. Given the limited resources of most countries with a schistosomiasis problem, it seemed important to attempt an evaluation of available control methods so that such economically poor countries might better be able to choose the method or methods appropriate for their particular conditions.

Accordingly, three possible control measures were selected for independent evaluation in St. Lucia--snail control, water supplies, and chemotherapy.

THE ST. LUCIA PROJECT

The West Indian island of St. Lucia measures about 1.4 miles wide by 28 miles long and is mountainous in configuration, with river systems flowing east to the Atlantic and west to the Caribbean. Three relatively isolated valleys, ideal for the purpose, were chosen as the field sites (Fig. 1). Snail control by using molluscides was evaluated in Cul-de-Sac Valley;[7-11] chemotherapy in Marquis Valley, and experimental water supplies in settlements on the southern side of Riche Fond Valley[12,13] (the comparison area being settlements on the northern side, with a government water supply).

Snail control

Cul-de-Sac Valley (population about 7,000) is roughly 1 mile wide and 7 miles long. Its flat-bottomed floor is covered with banana fields in which the root drainage system provides 600 miles of potential -- and frequently actual -- snail habitat.

Precontrol studies defined the transmission pattern. Biomphalaria glabrata, the intermediate snail host of S. mansoni, was found in a variety of flowing and static water habitats. Transmission was greater in the drier months of the year, this being a period of reduced flows for rivers and streams, with consequent buildup of snail populations. With the onset of the rains, these snail colonies were flushed out but static water habitats in the marshes and banana drains (dry in the months of little rain), became hosts to snail populations which sporadically became infected. Before they dry up in the months of low rains these static sites are believed to seed the rivers and streams with snails toward the end of the wet season.

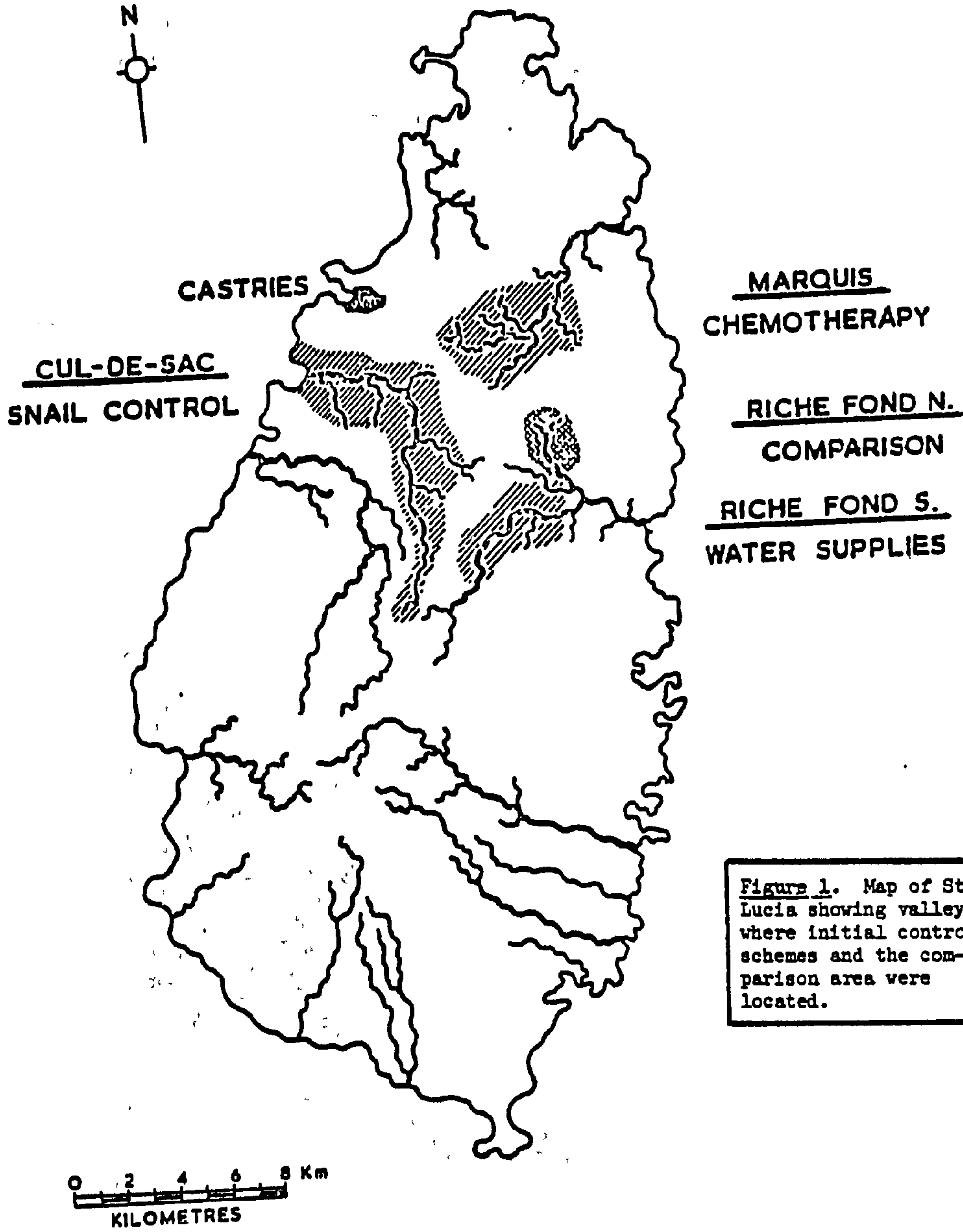


Figure 1. Map of St. Lucia showing valleys where initial control schemes and the comparison area were located.

Surveys of the human population of Cul-de-Sac showed that settlements on the valley floor had high levels of S. mansoni prevalence and intensity, while those on the hillsides had lower levels. (This same pattern was found in the other valleys, and results of control are therefore reported separately for high-transmission and low-transmission areas -- according to whether precontrol incidence of new infections was above or below 15% in children aged 0 to 7 years.)

Snail control by using a 25% emulsifiable concentrate of Baylascide was started at the end of 1970. A blanket treatment of all localities where snails had been found in precontrol studies was followed by a surveillance and treatment routine. Representative collections of snails found during surveillance, and sentinel snails exposed in natural water habitats, were returned to the laboratory, dissected, and examined for sporocysts. (The sentinel-snail technique was developed in St. Lucia in an attempt to monitor miracidial contamination of natural waters.[14] Laboratory-bred snails, contained in cages made of fibreglass netting, are exposed in streams or ponds for 24 hours; on being returned to the laboratory they are kept for 12 days, and then dissected and examined for sporocysts in the head-foot region. The 12-day interval allows differentiation from other trematode infections.)

By the 4th year of assessment, 1975, the numbers of snail colonies found in different types of habitat had been drastically reduced, and snails were confined to a much smaller area of the valley (Fig. 2).

The effect of this snail control program on S. mansoni transmission was monitored annually through human parasitological surveys (Fig. 3). The incidence of new infections fell from 22% between 1970 and 1971 to 4% between 1974 and 1975, thus reaching a level where it would be difficult to demonstrate any further significant reduction.

A 4-year cohort study of children aged >1 to 14 years showed the number of conversions or new infections (33) to be much smaller than the number of reversions or apparent lost infections (98), so that prevalence in the cohort decreased from 34% to 23%. During the same period, prevalence in a similarly aged cohort in the comparison area increased from 39% to 62% (Table 1).

With reduced transmission the prevalence and intensity of infection fell, resulting in a marked drop in the potential for contamination of the environment with S. mansoni eggs (measured by the product of the number of infected

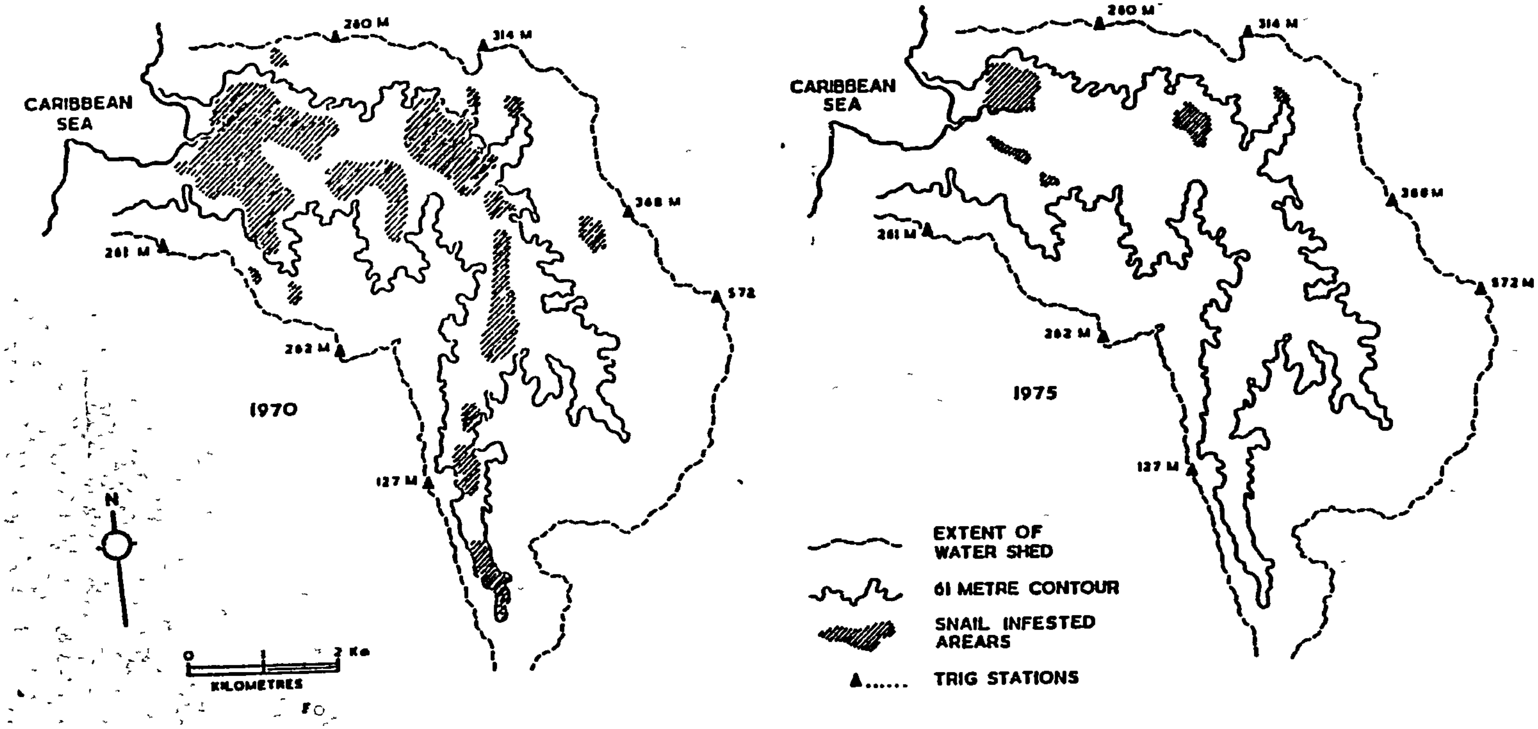


**Figure 2.** Location of Biomphalaria glabrata-infested areas in Cul-de-Sac Valley before and after 4 years of molluscициding.

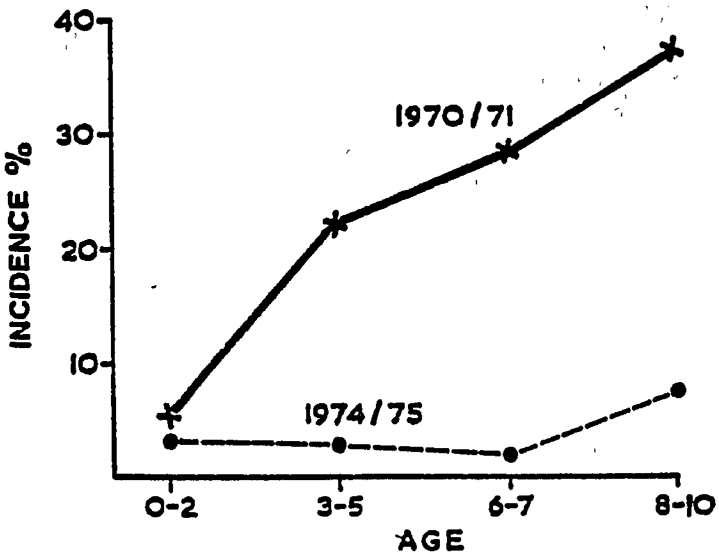


Figure 3. Incidence (%) of new *Schistosoma mansoni* infections in high transmission areas in Cul-de-Sac Valley between 1970-71 (the last year before control) and 1974-75, after 4 years of mollusciciding.

persons and the intensity of infection by age group) (Fig. 4). This was probably the reason for the reduced infection rate in sentinel snails, which fell from 3.9% (68 of 1,766) in 1971 to 1.1% (19 of 1,684) in 1974.

With transmission virtually stopped, treatment was offered to everyone in the valley found infected at the 1975 survey. Hycanthone at a dose of 2.0 mg/kg body weight was given to 649 persons. A focal control mollusciciding program has been introduced as a preliminary step to devising a scheme that can be handed over to the government health department. The 1976 survey, after chemotherapy, showed a further reduction in prevalence, and following this survey an additional 340 persons were treated with oxaminiquine at a dose of 15 mg/kg body weight (Fig. 5).

The future of this pilot scheme will depend on the results of a survey to be conducted in 1977.

Control through provision of water supplies

This method was evaluated in five settlements (population about 2,000) on the southern side of Riche Fond Valley. The comparison area consisted of six settlements on the valley's northern side, where a 1969 government water scheme provided communal standpipes at intervals along the road and at various points in the villages.

The design of the experimental water supply program called for a faucet in each house, but in two of the villages a few houses were located at such high elevation that more costly pumping equipment would have been needed to reach them. Instead, therefore, laundry-shower units were constructed as high up as possible for use by householders without an individual supply.

The Fordilla faucet provided is adjusted to deliver no more than 2 gallons at each activation. Since it cannot be left open, water wastage is eliminated. In the case of the showers, the Fordilla was modified for foot operation.

The laundry-shower units varied in size, the largest containing eight laundry tubs and four to six showers. Three simple swimming pools were also constructed.

The primary object of the domestic water supply was to reduce the villagers' contact with infective rivers and streams. In order to obtain baseline data, water contact studies were initiated precontrol at 15 selected river and stream sites; various forms of contact -- collecting of

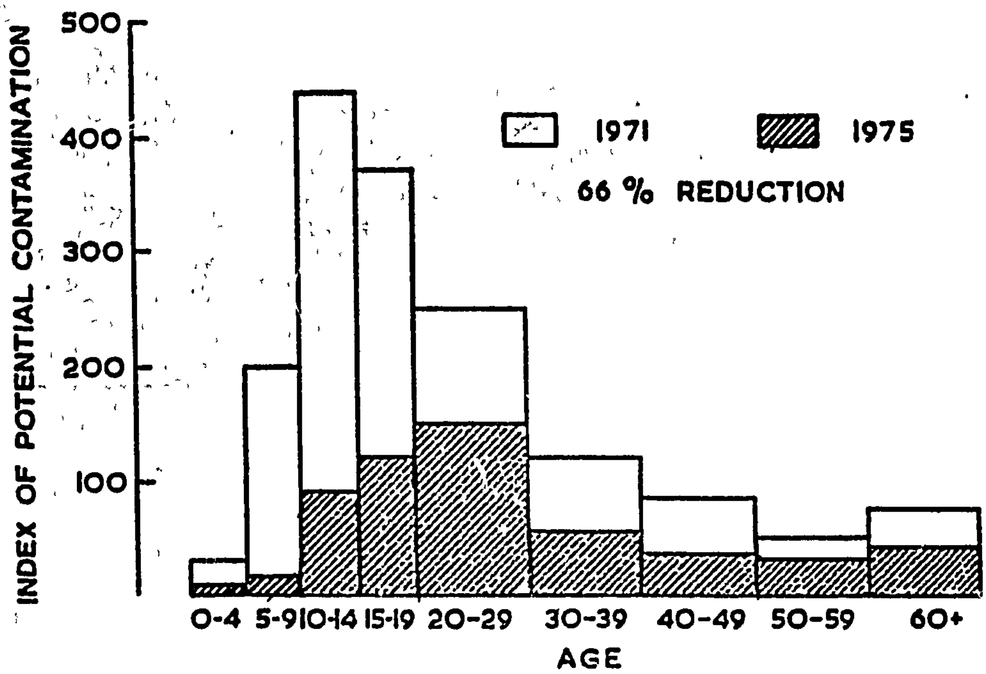


Figure 4. Index of potential contamination of water with S. mansoni eggs by age in high S. mansoni transmission areas of Cul-de-Sac in 1971 and in 1975.

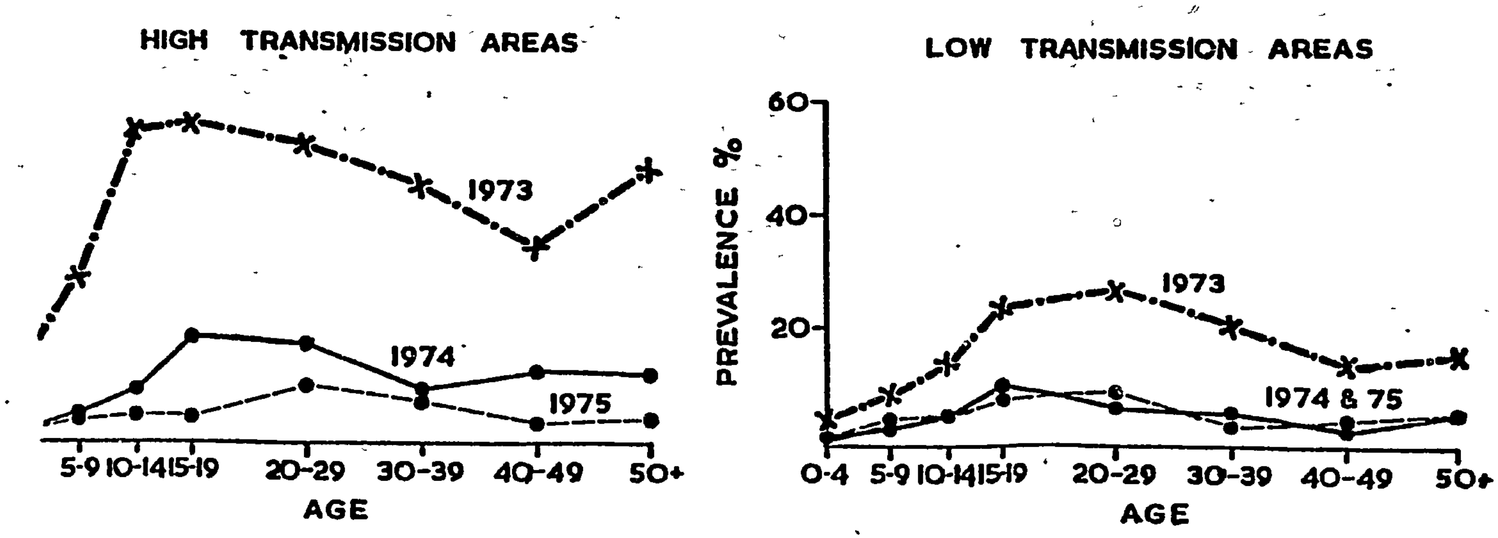


Figure 5. Prevalence (%) of S. mansoni infection in Cul-de-Sac in 1971 and 1975 (before and after 4 years of mollusciciding), and in 1976, 1 year after chemotherapy.

water to carry home, washing of clothes, bathing, playing--were observed over a 15-month period according to a statistically acceptable, balanced block design. Identical studies were then carried out postcontrol, with the same sites observed on the same days of the same weeks of the year as previously. (Personal communication --. Dr. Peter Dalton, Box M 190, Accra, Ghana).

Although the population had of course to be given some explanation as to why stool surveys were needed and water was being installed, no attempt at health education was made until the spontaneous response of the people to water supplies could be seen.

With water available for 5 months, observed contact with the rivers and streams for collecting water to carry home virtually ceased. Washing of clothes at the observation sites was reduced by about 60% and bathing by about 30%; however, the amount of swimming showed no change. An intensive health education campaign was then launched, and a laundry-shower unit was built close to the most popular river washing site. Thereafter, all observed contacts were reduced by about 90%.

The installation of the water system took place over 2 years, the first settlement being supplied in mid-1970 and the last in mid-1972. The incidence of new infections fell from 31% in the 12 months prior to water being provided in the first village (i.e. 1969-1970) to 12% in 1974-1975 (Fig. 6). That the effect on incidence was not greater is probably due to the local school and church being situated in the comparison area. In cohorts of children aged $>1$ to 14 years and followed between 1971 and 1975, prevalence fell from 47% to 42% for the study area but increased from 39% to 62% for the comparison area. The lower prevalence and intensity of infection in the experimental area led to a reduction in potential contamination there of 70% (Fig. 7).

Infections in sentinel snails fell from 0.5% (14 of 2,958 examined) in 1971 to 0.2% (16 of 2,919) in 1974. Although this fall can be attributed in part to reduced egg excretion, it seems possible that reduced contact with the river brought about less fecal contamination of the river banks.

By 1975, when the first village had had domestic water for 5 years, prevalence in all age groups had fallen from 72% precontrol (100% in the age group 15 to 19 years) to 36% (Fig. 8). Thus it is apparent that an adequate, reliable, and conveniently placed water supply can significantly

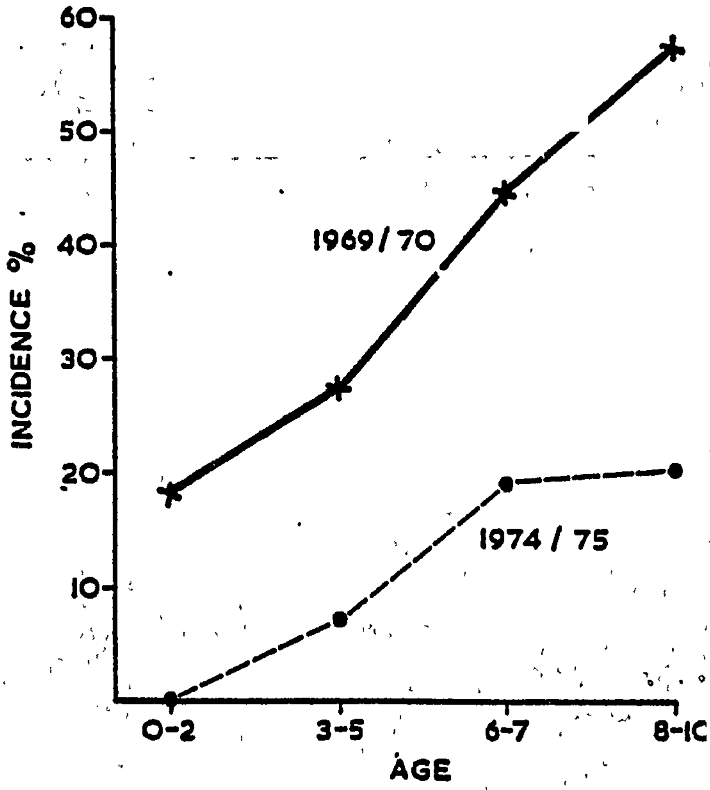


Figure 6. Incidence (%) of new S. mansoni infections in settlements where water supplies were installed to reduce contact of people with cercariae-infested streams. (The first village was supplied in 1970; the last in 1972.)

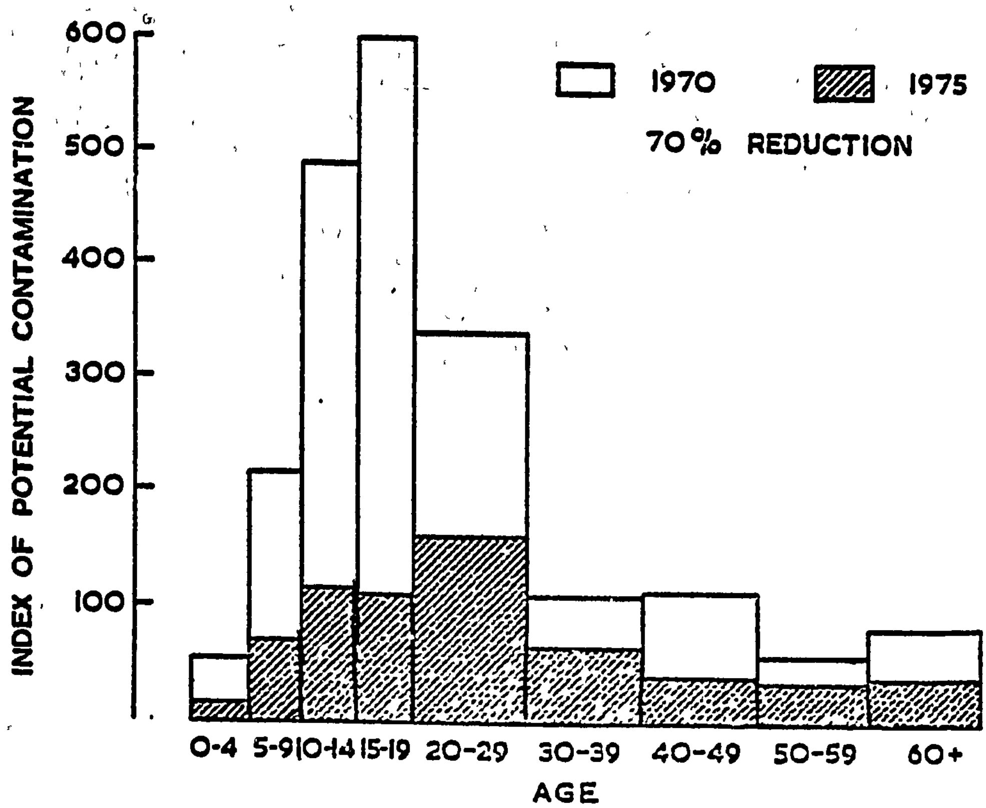


Figure 7. Index of potential contamination of water with S. mansoni eggs by age in settlements provided with a water supply to reduce contact of population with infected streams.

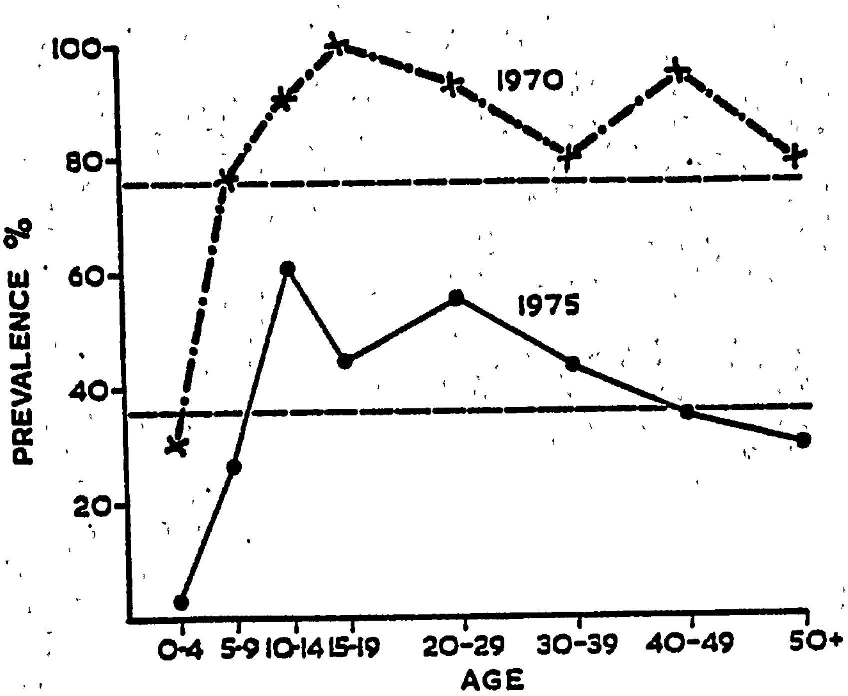


Figure 8. Prevalence of *S. mansoni* infection in 1970 in the first village to be supplied with water, and in 1975 after 5 years of water supplies.

affect S. mansoni transmission. Infected persons are now being offered treatment.

This experimental water supply may be considered too sophisticated for general use as a control measure. On the other hand, the government standpipe system in the comparison area has failed to affect transmission. Since it was installed in 1969, prevalence there has not fallen and in fact has risen--although not as a direct result. It is important, therefore, to consider the two schemes.

The government water scheme consisted solely of standpipes. During water contact studies in the comparison area there was virtually no observed contact by villagers with rivers and streams for the purpose of collecting water to carry home; the standpipe supply was relied on almost entirely in this regard. However, use of these waters for washing of clothes, bathing and swimming continued unchanged. The scheme cost $18 per head of population and did not reduce transmission of S. mansoni.

The per capita cost of the experiment supply, which did reduce transmission was $22. Even with household water available, some women preferred to wash clothes in the river; once a laundry unit was provided, however, they were persuaded to use it. As a consequence, the young children who used to play in the river while their mothers washed were no longer exposed to infection for several hours a day -- and neither, of course, were the women.

In all probability, the laundry-shower units constitute the most important feature of the experimental scheme. Such facilities have now been built in the comparison area to supplement the standpipe system, leading to an immediate 50% reduction in observed contact with rivers for the purpose of washing, bathing and swimming.

The three simple swimming pools constructed in the study area did not prove popular. The water became muddy from the feet of the children and despite chlorination the "static" water was considered unclean by parents. Swimming pools may be costly and unsatisfactory but it should be possible to maintain snail-free a few of the natural pools used by children in endemic areas and to encourage their use through health education.

## Control through chemotherapy

Few rigorous attempts have yet been made to evaluate chemotherapy as a control tool. At the most recent meeting

(1973) of a World Health Organization expert committee on control,[16] five projects using chemotherapy were reviewed but none measured the impact on incidence of new infections among children, the only way to assess the effect of chemotherapy on transmission.

In Marquis Valley, St. Lucia, hycanthone at a dose of 2.5 mg/kg body weight was offered to all persons found with S. mansoni infection. A total of 677 patients received treatment after a survey in 1973, and 159 after a second survey in 1974. The 96 found infected at the 1975 survey were treated with oxamniquine.

In the high transmission settlements, incidence among children aged >1 to 10 years fell from 18.8% to 5.1% in the year after the first treatment campaign and to 1.1% after the second treatment campaign (Fig. 9). In the settlements with initially low rates of transmission, incidence in this age group dropped from 5% to 2% after 1 year but showed no further decline in the second year.

These changes were reflected in prevalence rates among all age groups (Fig. 10). In the high-transmission settlements, prevalence dropped further after the second treatment; in the low-transmission settlements, it remained virtually unchanged. Thus, it seems comparatively easy to produce a rapid and significant lowering of a high prevalence rate, but difficult to reduce further an already low rate.

Of the 96 persons found positive for S. mansoni in 1975 (i.e., after two treatment campaigns), 4 were treatment failures, 16 were immigrants to the valley (representing 10% of immigrants) and 76 had apparent new infections. However, 36 of the latter were known to have been S. mansoni positive in precontrol surveys, and the other 40, although not previously found positive, could have had light chronic infections that were missed on other surveys. Such cases are liable to turn up at future surveys for several years to come, a situation that would be eliminated if all persons were treated instead of only infected persons.

Sentinel snails were exposed in different parts of the valley for 2 years before chemotherapy, and 56 of the 3,790 examined proved to be infected (1.48%). Since completion of the first treatment campaign, however, not one sentinel snail has been found infected in nearly 5,000 examined. The picture for wild snails collected from index sites is much the same: before control, 10% (114 / 11,400) infected; but since chemotherapy, only one of over 30,000 infected. These findings support the parasitological data and indicate that transmission must be at a very low level.

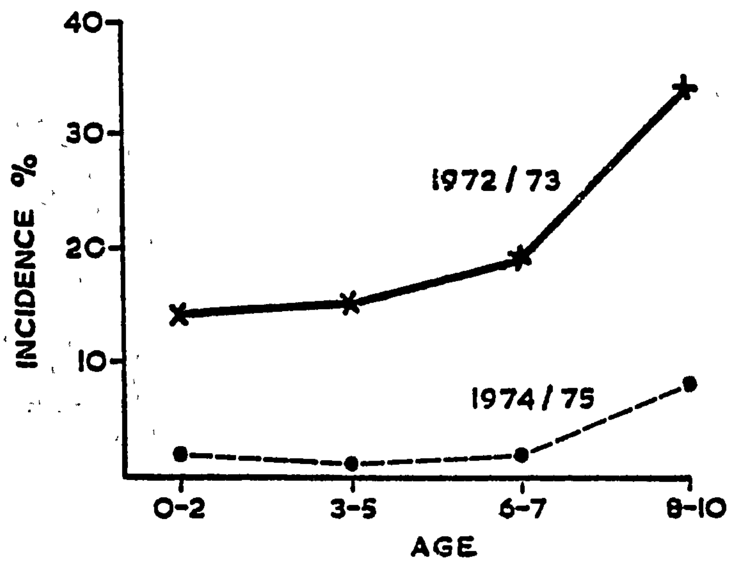


Figure 9. Incidence (%) of new *S. mansoni* infections in high transmission areas of Marquis Valley between the years 1972-1973 and 1974-75, after two chemotherapy campaigns.

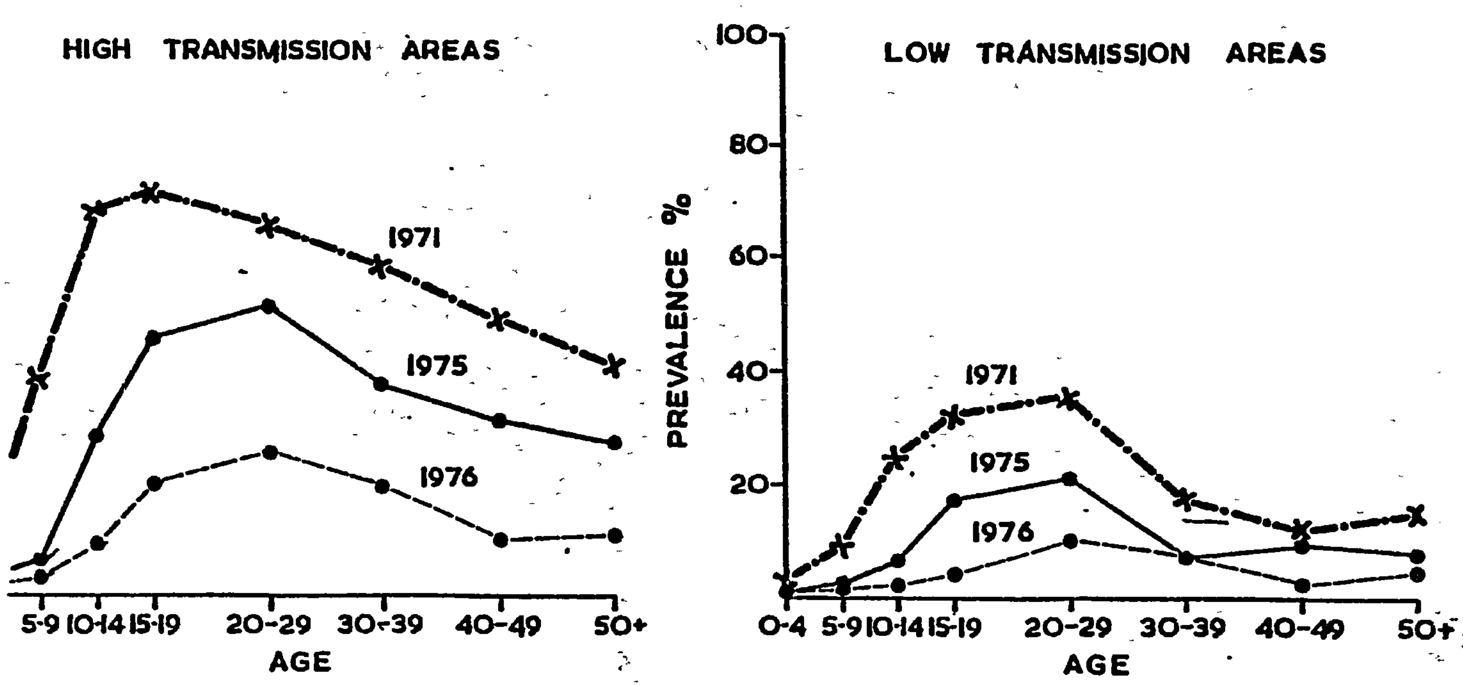


Figure 10. Prevalence (%) of S. mansoni infection in Marquis Valley in 1973, and in 1974 and 1975, after one and two chemotherapy campaigns.

# TABLE I.

Results of a 4-year old cohort studies among children aged --1 to 14 years of age in Cul-de-sac and the comparison area

| Area | No. Exam. | No. (%) positive-'71 | Con-versions | Rever-sions | No. (%) positive-'75 |
|---|---|---|---|---|---|
| Cul-de-Sac | 643 | 216(34) | 33 | 98 | 151(23) |
| Comp-arison | 528 | 204(39) | 165 | 44 | 325(62) |

* Conversions are children whose stools were negative for S. mansoni eggs in 1971 but positive in 1975
+ Reversions are children whose stools were positive in 1971 and negative in 1975.

The three schemes compared

It seems clear that all three experimental control schemes have reduced transmission. The only parameter by which they can be compared is the incidence of new infections. As the schemes were started at different times, comparison is necessarily restricted to the 2 years for which results are available from the chemotherapy control scheme.

In this 2-year period, incidence of new infections was reduced from 18.8% to 4.1% with chemotherapy, from 22% to 9.8% with snail control, and from 22.7% to 11.3% with provision of domestic water supplies. It should not be forgotten that whereas molluscicidìng involved an entire watershed and control could therefore encompass the whole valley within a short length of time, the experimental water scheme took 2 years to install and the incidence data included one settlement supplied for only a year. Further, the water scheme area was within a half mile of the large, "uncontrolled" comparison area. If these points are taken into consideration, there is actually very little difference in results between the snail control and water supply schemes. A comparison of the changes in potential contamination for the two schemes bears this out; from 1970 to 1975, a fall by 70% in the settlements supplied with water; from 1971 to 1975, a fall by 66% in the snail control scheme.

Costs are important in a comparative evaluation such as this, and as detailed a cost analysis as possible has been kept. The respective annual costs per capita of the schemes during the first 2 years were: $1.10 for chemotherapy, $3.70 for snail control, and $4.00 for water supplies.

The capita cost of chemotherapy falls as the number of persons to be treated declines, but will not drop below the cost of case detection -- if only infected persons are treated.

The cost of water supplies increases as more maintenance and repairs are required and the cost of electricity rises (about half the maintenance costs are for electricity that would not be needed in a gravity-fed system). Molluscociding costs remained approximately unchanged, the decreased cost of molluscicide being balanced by increasing wages paid for labor.

The three basic approaches to schistosomiasis control tried in St. Lucia appear to have produced satisfactory results, but the question is frequently asked: "How reproducible are these results elsewhere, since St. Lucia is not typical of other endemic areas?" Whether a typical endemic area exists anywhere seems doubtful, but certainly the mollusciciding strategy developed for St. Lucia will not be applicable in many other locations. This scheme does show, however, that even with a complex pattern of transmission at all times of the year and dependent on climatic variations, an appropriate technique can be worked out and transmission significantly reduced. The series of papers by Sturrock and his co-workers[7-10] describing the methodology employed in devising the strategy, will surely remain a standard of reference for many years.

The other two approaches involved the definitive host-man. The means by which he passes on his infection are the same in all endemic areas. The experimental water supply scheme was aimed at preventing infection from occurring, and the chemotherapy scheme at preventing it being passed on. There may be different responses as to the acceptance of these two control techniques, but both are generally acceptable.

In answer to the question, then, results from St. Lucia will not be reproducible in every situation, but the methods of control found to succeed there deserve consideration in other areas where an effective control scheme is required.

## ADVANTAGES AND DISADVANTAGES OF DIFFERENT APPROACHES

After 10 years of operational research, what comments can we make on control?

Mollusciciding can effectively control transmission, but the strategy used must be based on biologically sound principles and may necessitate extensive precontrol study. Snail control requires little cooperation from the community, and is effective in the face of immigration of infected persons. When applied focally to main transmission areas, it may reduce prevalence among the heavily infected individual, and morbidity from the disease will be reduced only after many years of control. There are no other medical benefits derived from mollusciciding, though in some areas transmission of fascioliasis may be reduced.

Water supplies are effective in reducing transmission, but only in the immediate area where they are installed. They need a capital investment, which may not be excessive if water is readily available -- as in the great lakes and in irrigation schemes. Since water supplies are usually wanted by a community, support for them is not hard to mobilize. As a control method, they are not affected by population movement. While affecting schistosomal disease only slowly, they offer other important social and medical benefits. Now that water is being provided in many developing countries, health departments should be made aware of the potential value of water supplies as a method of schistosomiasis control, and should be encouraged to add to water schemes those facililes which specifically discourage continued contact with infective waters.

Chemotherapy appears to be the cheapest, most rapid, and most effective method of controlling transmission. It also is effective in disease control. However, it probably requires a high degree of cooperation from a stable community, and thus may be less satisfactory where unchecked immigration of infected persons occurs.

UNSTUDIED ASPECTS OF CHEMOTHERAPY

Chemotherapy is obviously going to be of increasing importance in control, but much research is needed into its delivery and use as a control tool. In 1965 a WHO Expert Committee stated: "Control of transmission (of bilharzia) by chemotherapy has not proved feasible in the past for a number of reasons, mostly concerning the lack of a satisfactory drug, easily administered over a short period of time, free from side effects, and producing a high rate of parasitologic cure."[16] Now that some available drug -- and others currently being evaluated -- come close to meeting these requirements, we find many unanswered questions relating to drug delivery. The main one is -- who should be treated, and how often?

There is probably no simple answer; much will depend on the epidemiological conditions. Mass chemotherapy, or the treatment of as large a proportion of the population as possible, would seem ideal but may not be feasible or advisable. Some form of selective treatment is therefore necessary. Treating only those persons with detected infections, as in the St. Lucia project, means that many infected persons go untreated because of their failure to provide material for examination or because their light infections are missed on examination.

But other forms of selective treatment are possible -- treatment of all persons, or only those infected, in the age groups responsible for most contamination of the environment. In tanzania, for example, the age groups from 6 to 19 years were responsible for 75% to 95% of contamination in three areas where S. haematobium was endemic.[17] Treatment of these groups would reach many with schistosomal disease, but it is not known how effective this would be in controlling transmission. Similarly, we do not know the effect on transmission of treating only persons excreting over 500 eggs/g of stool, as has been done in Kenya.[18] In spite of an 80% reduction in contamination, the remaining 20% in this area is likely to be sufficient for continued high-level transmission. Control of disease among those treated would no doubt occur, as in Brazil where the treatment of all persons aged 10 to 19 years with a high egg output (500 or more eggs/g of stool) has been advocated for disease control.[18]

Where prevalence and intensity of infection have been reduced to a low level and presumably the infection is of little public health importance, we do not know how long such a state of affairs will last. Since the frequency of necessary retreatment is likely to depend on the epidemiological situation, some system of monitoring transmission may be required -- perhaps the examination annually of children aged 5 to 9 plus the families of any found infected. Alternatively, one could envisage routine reexamination and re-treatment at 5-year intervals.

These questions on the specific application of chemotherapy for control, alone and in combination with other approaches, should receive high priority for investigation in different epidemiological situations.

In 1967, molluscciding appeared to be the only practical and effective method of control. Certainly for S. mansoni, however, three methods can now be considered. While there will never be a blueprint to suit all epidemiological situations, chemotherapy surely holds the key to control in the future and we should make use of it since it is rapidly effective for transmission and disease control. To overcome the disadvantages of requiring a high level of cooperation and being hampered wherever immigration is a problem, it should, for long-term control, be complimented by a mollusciciding program (perhaps focal) or with adequate water supplies.

To sum up, there is still a frontier to cross, but it is at last within sighting distance.

REFERENCES

1. Yokogawn, M., 1972. Control of schistosomiasis in Japan. Pages 129-132 in M.J. Miller, ed., Proceedings of a Symposium on the Future of Schistosomiasis Control. Tulane University, New Orleans.

2. Faria, H.F., 1972. Control of schistosomiasis in Venezuela. Pages 100-103 in M.J. Miller, ed., Proceedings of a Symposium on the Future of Schistosomiasis Control. Tulane University, New Orleans.

3. Farooq, M. Hariston, N.G., and Samaan, S.A., 1966. The effect of area-wide snail control on the endemicity of biharziasis in Egypt. Bull. W.H.O., 35:369-375.

4. Pesigan, T.P., and Hariston, N.G., 1961. The effect of snail control on the prevalence of Schistosoma japonicum infection in the Philippines. Bull. W.H.O., 25:479-482.

5. Pitchford, J., 1966. Findings in relation to schistosome transmission in the field following the introduction of various control measures. S. Afr. Med. J. 40(suppl.):3-16.

6. Barbosa, F.S., Pinto, R., and Souza, O.A., 1971. Control of schistosomiasis mansoni in a small northeast Brazilian community. Trans. R. Soc. Trop. Med. Hyg., 65:206-213.

7. Sturrock, R.F., 1973. Field studies on the population dynamics of Biomphalaria glabrata, intermediate host of Schistosoma mansoni on the West Indian island of St. Lucia. Int. J. Parasitol., 3:165-174.

8. Sturrock, R.F., 1973. Field studies on the transmission of Schistosoma mansoni and on the bionomics of its intermediate hosts, Biomphalaria glabrata, on St. Lucia, West Indies. Int. J. Parasitol., 3:795-801.

9. Sturrock, R.F., 1973. Control of Schistosoma mansoni transmission: Strategy for using molluscicides on St. Lucia. Int. J. Parasitol., 3:795-804.

10. Sturrock, R.F., Barnish, G., and Upatham, E.S., 1974. Snail findings from an experimental mollusciciding programme to control Schistosoma mansoni transmission on St. Lucia. Int. J. Parasitol., 4:231-240.

11. Jordan, P. Woodstock, L., and Cook, J.A., 1976. Preliminary parasitological results of a pilot mollusciciding campaign to control transmission of Schistosoma mansoni in St. Lucia. Bull. W.H.O., 54:295-302.

12. Unrau, G.O., 1975. Individual household water supplies in rural St. Lucia as a control measure against Schistosoma mansoni. Bull. W.H.O., 53:1-8.

13. Jordan, P., Bartholomew, R.K., Unrau, G.O., and Cook, J.A., 1975. Control of Schistosoma mansoni transmission by provision of domestic water supplies. Bull. W.H.O., 52:9-20.

14. Upatham, E.S., 1972. Exposure of caged Biomphalaria glabrata (Say) to investigate dispersion of miracidia of Schistosoma mansoni Samboa in outdoor habitats in St. Lucia. J. Helminthol, 46:297-306.

15. World Health Organization, 1973. Schistosomiasis control. Report of a WHO Expert Committee. Tech. Rep. Scr. No. 515.

16. World Health Organization, 1965. WHO Expert Committee on Bilharziasis. Third report. Tech. Rep. Scr. No. 299.

17. Jordan, P., 1963. Some quantitative aspects of biharzia with particular reference to suppressive therapy and mollusciciding in control of S. haematobium in Sukumaland, Tanganyika. East Afr. Med. J., 40:250-260.

18. Siongok, T.K.A., Mahmound, A.A.F., Ouma, J.H., Warren, K.S., and Houser, H.B., 1976. Morbidity in schistosomiasis mansoni in relation to intensity of infection. Am. J. Trop. Med. Hyg., 25:273-284.

19. Kloetzel, K., 1974. Selective chemotherapy for schistosomiasis mansoni. Trans. R. Soc. Trop. Med. Hyg., 69:344.

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# FINDINGS

## I. The Magnitude of the Problem in Relation to Socio-Economic Development Potential in Africa:

The adverse impact of onchocerciasis on the quality of life and on socio-economic development in Africa is as previously described by participants in various international symposia (e.g. "Tunis Meeting Report," 1968; "Onchocerciasis in the Western Hemisphere," 1972; and "Epidemiology of Onchocerciasis," 1973). Although the economic impact of the disease is recognized as an important reason for undertaking control programs, more emphasis should be placed on the need for control in order to free the people from the depredations of onchocerciasis as a major disease.

There are large areas in Africa, and to a lesser extent in other parts of the world, where onchocerciasis is a highly endemic disease of serious clinical import, but where no comprehensive control programs are yet being undertaken. Many of these endemic areas, particularly in the African savanna, involve river valleys which comprise a high proportion of the most fertile lands in the countries concerned. The reasons why people abandon such areas and stay away from them are varied, but one of the most important is the fear of river blindness.

The magnitude of the onchocerciasis problem, occurring at the community level, warrants action by responsible officials at the national and international levels. However, the decision to initiate control programs within a country or within neighboring countries must be an internal one. An increased awareness, at the community level, regarding the relationship between black-flies and onchocerciasis would contribute to the demand for control programs, as well as to their acceptance and success.

Onchocerciasis control undoubtedly increases community self-sufficiency. The individual and the family become more self-sufficient when freed from the incapacitating effects of this disease. As a result, the entire community benefits. However, in addition to controlling transmission, it is also necessary to identify and treat those individuals who are threatened by onchocercal blindness. Treatment of infected individuals should not be limited to those in which the diseases has progressed to the blindness stage.

Onchocerciasis control should figure prominently in both health and economic development plans with the priorities established by the countries concerned.

## II. Current Control Measures and Their Suitability for Application in Africa:

A. The criteria that need to be taken into consideration in selecting an area for onchocerciasis control are:

1) the local epidemiologic importance of the disease, in terms of the prevalence and intensity of infection, and the occurrence of eye lesions;
2) the socio-economic importance of the disease, including desertion of the affected area;
3) the extent of the area and its degree of isolation from other known foci of the disease;
4) the interest shown in the area by the governments concerned;
5) the basic knowledge of the area, such as cartography, hydrology, entomology, parasitology, ophthalmology, human geography and the possibilities of resettlement;
6) the logistics, such as transportation and communication;
7) the availability of insecticides, procurement, storage and formulation;
8) the suitability of present <u>Simulium</u> larviciding techniques for use in the area concerned;
9) the availability of skilled personnel, as well as financial and logistic means to implement field studies and the campaign.

B. The need for distinguishing between vector control, filarial control of <u>O. volumlus</u> infection, and disease control was discussed; and it was emphasized with regard to parasitic and disease control. The following was noted:

1) that it is difficult to obtain an accurate assessment of the prevalence of the infection;
2) that greater efforts should be made to determine the incidence of infection in order to assess the effects of control measures;
3) that emphasis should be placed on the need for research to develop more sensitive diagnostic techniques with regards to vector control;
4) that an attempt should be made to obtain unreported epidemiologic data and to conduct onchocerciasis surveys in areas for which data are not available:
    (a) the geographic distribution and the biology of the vector in Africa should be further studied; and

(b) the importance of making entomological investigations at an early stage should be stressed, and those should include a study of the sibling complexes in the vectors.

C. Presently in Africa, larviciding against the vectors is the only practicable method of controlling onchocerciasis. Simulium larvicidal control schemes are generally costly, and in many parts of Africa, they may not be feasible. The majority of Africans suffering from onchocerciasis are unlikely to benefit from the effects of such control in the immediate future. Efforts should be made to develop simple "environmental behavioral" methods for reducing risk of man/fly contact. These methods should be such that they can be put into operation by the people on an individual or community self-help basis. To promote these self-help methods adequate health education programs should be instituted.

Educational guidance should include instruction in the use of protective clothing and repellents, the location of villages and of human activities in relation to Simulium biting sites, and the provision of good water supplies (e.g., deep wells) away from Simulium breeding rivers.

D. Other measures currently available for control of onchocerciasis were discussed, along with their limitations and their advantages:

1) Nodulectomy -- Control by means of large-scale nodulectomy campaigns has been going on in Guatemala since 1933. In a country where head nodules are common, this measure alone is reported to have reduced the incidence of blindness. In West Africa, a correlation has been demonstrated between onchocercal eye lesions and the presence of nodules on the head. However, not more than one in four patients with such eye lesions showed palpable head nodules. Furthermore, in many cases, the eye lesions had already developed by the time the nodules were palpable. Consequently, removal of head nodules only on a large-scale would probably be of limited value. (WHO has designed a project to evaluate the effect of total nodulectomy in the OCP area.)

A high concentration of microfilariae in the skin near the eye has been shown to be a good indicator of danger to the eye. Using the corneo-scleral punch/microtiter plate technique, it is relatively easy to screen a population for the presence of microfilariae near the eye. It should then be possible to bring those cases which are at the risk of developing blindness to early treatment.

2) Chemotherapy -- Those treatments discussed are as follows:

(a) Suramin, given intravenously in 4-6 weekly injections, is an efficient macrofilaricide; and it also has some action against the microfilariae. It has been used in large-scale treatment campaigns, against onchocerciasis in Venezuela, where the infection with *O. volvulvus* is generally light. In Africa, it is not often used for large-scale treatment. It is difficult to administer and particularly in heavily infected patients, it may produce dangerous reactions. However, it is still the best drug for treatment of individual cases, where there is a particular risk of blindness. (WHO has designed studies to evaluate the effect of small doses of Suranim, and to study its toxicity.

(b) Diethylcarbamazine (DEC) is a most efficient microfilaricide, but it has no effect on the adult worm. Its action on microfilariae gives rise to severe and unpleasant side effects. Therefore, it is not acceptable for mass treatment in heavily infected communities. Suppressive DEC, i.e. weekly low-dose (50 mg) administration, following a standard microfilaricide course of the drug, can keep the microfilarial load at a low level. Such suppressive schedules have been tested on a small scale in Mali, northern Ghana and in Cameroon. However, because of the recurrent itching, they were not sufficiently popular to be continued by the patiencs on a voluntary basis. The mode of action of DEC and the best ways of combining it with Suramin in the treatment of cases at risk of going blind are being studied in WHO-supported projects.

(c) Metrifonate is a less efficient and lower acting microfilaricide than DEC. It is more acceptable to the patient because of the less severe side effects. The possibility of using metrifonate in large scale treatment will be studied in the Onchocerciasis Control Program in the Volta River Basin.

3) Chemoprophylaxis. There is at present no practical chemoprophylaxis against onchocerciasis.

(a) opportunities should be made available for qualified students to pursue post-graduate studies in health-related sciences;
(b) one-year post-doctoral programs with emphasis on tropical medicine and public health should be instituted;
(c) efforts should be made to avoid narrow specialization;
(d) professional personnel should be capable of adapting to changing public health needs; and
(e) practical on-the-job training should be available as part of the existing control programs.

2) There are probably not more than 15 opthalmologists in the world who have significant field experience of onchocerciasis, and they are mainly from outside of Africa.

(a) there is an urgent need for the training of African opthalmologists;
(b) it would also be extremely useful to give field training in onchocerciasis and other eye diseases to a greater number of non-African opthalmologists.

## D. Places in Africa Where Control Programs Might Be Undertaken

The techniques of aerial larvicide spraying, used in the Onchocerciasis Control Program in the Volta River Basin (OCP), are satisfactory and could be used after a careful assessment of the local situation in similar areas of Africa. However, aerial spray techniques would not be suitable for use in the following areas: foci where *Simulium neavi s.l.* is the vector or one of the vectors; and forest foci where *Simulium damnosum s. l.* breeds in small rivers concealed by the forest canopy. The known distributions of onchocerciasis and its *Simulium* vectors are shown on maps in the report of the World Health Organization Expert Committee on the Epidemiology of Onchocerciasis (1976, figs. 1 and 3).

From the viewpoint of control, the major foci of African onchocerciasis may be classified topographically as follows:

a) those which are contiguous with the existing Onchocerciasis Control Program in the Volta River Basin (OCP);
b) those which are predominantly of the "forest" type and may be associated with significant blindness rates (mainly due to lesions of the posterior segment); but which do not lead to desertion of land or provide a serious impediment to socio-economic development;

c) those which are predominantly of the "Sudan-savanna" type, i.e. sometimes associated with very high blindness rates, desertion of land and prevention of economic development; and
d) those which are effectively isolated from foci.

2. Foci contiguous with OCP -- Those foci in West Africa, whether of "Sudan-savanna" or "forest" type, which are contiguous with the present OCP area, can probably be controlled most logically and effectively by means of extensions to that project. This might include a number of foci in Benin, Ghana, Guinea, Ivory Coast, Mali, Nigeria and Togo.

3. Foci of "forest" onchocerciasis -- Considerable and extensive areas of "forest" onchocerciasis are to be found in:
1) Liberia/Sierra Leone;
2) southern Cameroon and the adjacent parts of southern Nigeria; and
3) Zaire, especially in the Kasai/Sankuru focus, and the Oubahgui and Tsuapa areas of the equator region

In many of these areas, blindness due to onchocerciasis may be more prevalent than is generally assumed. However, the areas concerned are large and methods for large-scale and widespread larviciding in forest areas have not yet been worked out. The Kasai/Sankuru focus in Zaire may be singled out as the "forest" focus meriting control priority, because of its manageable size, and because of the extreme severity of eye lesions therein.

4. <u>"Sudan-savanna" foci</u> -- The most important foci of onchocerciasis occur in the Sudan-savanna areas. Here there are high blindness rates. In some of the foci economic development and/or resettlement are impeded by onchocerciasis. In all of them, it is probable that current aerial larviciding control methods could be used.

The most significant foci where little or no control is being undertaken at present are:

1) in eastern Senegal;
2) at the junction of Cameroon, Chad and the Central African Empire, and
3) in the southern Sudan, centered on the Bahr-el Ghazal and Equatorial Provinces.

In terms of the number of people involved, the area of land affected, and the severity of the disease as a cause of blindness, the southern Sudan focus is, without a doubt, the most important of these areas. It compares in the above respects with the present OCP area; it is currently believed to be a cause of considerable concern to the government of the Sudan; yet, there is a grave lack of the basic data necessary for implementing larvidical control.

5. <u>Isolated foci</u> -- In the extreme eastern portion of the endemic areas of onchocerciasis in Africa, there are a number of small separate foci of predominantly "forest" onchocerciasis in Tanzania and in Malawi. These scattered foci are probably isolated from the other main African foci, and also to a considerable extent from each other, both in relation to vectors and parasite. The vectors in most of these foci are members of the <u>S. damnosum</u> complex, but in others the <u>S. neavei</u> complex is involved.

For these foci, there is a possibility that control, once initiated, might lead to eradication (sic) of the vector in some or all of them. This has already been achieved in the Kodera valley focus in Kenya (<u>S. neavei</u>). These foci should be considered for control, and as sites where there may be a possibility of eradicating isolated vector <u>S. damnosum</u> populations for the first time.

## <u>Reason Why Control Is Not More Widely Applied</u>

A. Although it is clear that a satisfactory method exists for controlling the <u>Simolium damnosum</u> complex vectors in the savanna parts of Africa, there has been little application of the control method outside of the Volta Basin OCP. At present, this is the only major control scheme in operation anywhere in Africa.

B. The main reasons why more extensive use has not been made of existing control technology are noted as follows:

1) inadequate basic data to reveal the existence of onchocerciasis in certain areas; or the extent of the problem in those foci where it is known to exist;
2) inadequate appreciation by national or international authorities of the importance of onchocerciasis and of the need for its control;
3) insufficiency of resources to deal with the problem when its importance is recognized i.e., lack of money; the competing demands of other major diseases; and shortage of suitably trained personnel.

## CONCLUSIONS

1. At present, larviciding against the vectors is the only effective onchocerciasis control method in Africa.

2. There are several other technologies that can be used as supplementary control measures to a limited extent, e.g., nodulectomy, chemotherapy, and relocation of villages.

3. Except for the Onchocerciasis Control Program area, fundamental data necessary for the planning of control programs are insufficient.

4. One of the most serious constraints to the knowledge and control of onchocerciasis is the shortage of trained personnel.

5. US/AID has a vital role to play in the control of onchocerciasis in Africa.

## RECOMMENDATIONS

1. Larviciding for the control of *Simulium* vectors should be employed more widely in large or in ecologically isolated foci.

2. Chemotherapeutic and other methods of control should be used to supplement vector control whenever they become available.

3. The governments of countries in those areas listed in this report, where onchocerciasis is hyperendemic with high levels of blindness, should be approached forthwith with a view to assessing the feasibility of control.

4. Support should be provided for the academic and field training of personnel required to plan and carry out operational control programs.

5. US/AID and other potential donors should consider the providing of financial assistance to, and collaborating with, those countries interested in setting up onchocerciasis control programs.

## GROUP B: SCHISTOSOMIASIS

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# FINDINGS

## I. Magnitude of the Problem in Relation to Socio-Economic Development Potential of Africa

### A. The Rationale of Schistosomiasis Control

1. Only in a few instances has a water resources programme been impeded in its planning or early stages of development, solely on account of consideration of the spread of schistosomiasis that could ensue. In many instances schemes introduced without any control system have resulted in two adverse consequences: failure to develop fully the potential of the project; channelling of funds to control the subsequent spread of schistosomiasis at the expense of further development schemes.

2. There is an undeniable need for the development of water resources in Africa to meet the growing demands for food and energy.

3. In schistosomiasis endemic areas these programmes will inevitably result in an increase both in the prevalence and the intensity of the infection unless preventive measures are introduced right from the planning stage, implemented during the development programme and subsequently maintained.

4. These facts have been appreciated for some years, but even today, there are too many instances where water development and other engineering projects have been completed with little or no prior consideration having been given to the problem of schistosomiasis and its control. All too often serious attention is first drawn to the matter only after a serious health problem has developed.

5. This regrettable state of affairs stems from two main causes:

    1) A failure of communication at all levels between the several disciplines and bodies involved in water-resources development programmes;

    2) A lack of awareness on the part of the planners, engineers, economists, administrators, etc. of the inevitable spread of schistosomiasis and a lack of conviction on their part of the economic and social importance

of the infection.

6. It is beyond dispute that schistosomiasis infection may lead to gross pathological changes in the body which in time become irreversible. In association with malnutrition or with other infections with which the disease is so often found, a lowering of community well-being and a rising morbidity and mortality is inevitable. It is true that it has not been possible to quantify precisely the social and economic impact of schistosomiasis infection in terms either of the individual or the community level, even in areas of high endemicity. This is due to the subsistence level of the economy, the lack of adequate data and reliable methodology to analyze accurately the situation, and the long term and insiduous nature of the problem.

7. The spread of schistosomiasis, following the development of water resources, is often on a large scale with the appearance of high prevalence worm burdens in large populations. The sheer magnitude of the ensuing endemicity is argument enough to demand that preventitve measures be a part of such schemes. Multiplication of such programmes with inadequate control provisions, will, within a decade or two, present national authorities with a problem beyond their resources.

8. In the rural areas, where schistosomiasis occurs, resources for medical care are very limited. It is unacceptable that a water development project, because of inadequacies in its planning and implementation, be permitted to impose an unnecessary additional strain on natural resources by creating a stream of schistosomiasis patients requiring treatment.

9. All countries in tropical Africa have an inherent schistosomiasis problem. As a reflection of factors associated with increasing population, the prevalence and intensity of schistosomiasis can be expected to rise. It is the result of water resource development that the most threatening situations will occur. For the time being, attention must in general be focused on such developmental schemes.

10. In the funding of water development projects adequate provision must be made for the introduction of measures to control schistosomiasis from the outset and to maintain these measures indefinitely at a high level of efficiency.

11. Careful and adequate studies to quantify the economic and social effects of schistosomiasis should be undertaken in different conditions in areas where the disease appears to be important.

## II. Current Control Measures and Their Suitability for Application in Africa

Successful application of schistosomiasis control measures in any given area in Africa requires sound epidemiological knowledge about the area, appropriately trained personnel at all levels of application, and sufficient political support; long-term funding is desirable, even essential, and must include adequate support for maintenance. The difference between disease control and transmission control is critical and should be fully recognized.

All varieties of known control measures have been applied either singly or in combination in Africa. Schistosomiasis control measures have been described in detail in previous documents prepared by WHO, AID, and other agencies. Below are briefly summarized the types of activities discussed:

1. At the outset, it must be emphasized that health education is a critical factor in successful application of any control measure. Health education should be part of any control program from its inception.

2. Snail control programs in Africa use the range of available molluscicides, with varying success. Habitat modification by use of engineering measures has also been part of snail control programs. Potential techniques of snail control include the use of biological measures, especially local plant materials. Recognition was given to the concern that long-term molluscicide application may adversely affect human and natural environments.

3. Chemotherapy is expected to play an increasingly larger role in schistosomiasis disease control in Africa. Success of existing drugs in chemotherapy campaigns has been reported. These drugs include antimony compounds, niridazole, metrifonate, hycanthone, and oxamaniquine. Dosages, however, may differ from one region to another, due to different schistosome strains. New drugs, still being tested, may enable rapid reduction of prevalence to

even lower levels. Successful mass chemotherapy campaigns, depend to some extent on stable, cooperative populations. Local plants may play a useful role in chemotherapy; their potential should be investigated.

4. Mechanisms that limit human contact with snail-infested water have been shown to be effective in schistosomiasis control and also in the reduction of other diseases. These procedures involve the provision of safe and convenient community water supplies, the reduction of contact with snail-infested waters, and the provision of waste disposal facilities. Strong emphasis must be given to local participation in the planning, operation and maintaining of such intervention procedures.

5. Every effort must be made to encourage local participation in all phases of the control programs and in the adoption of control measures. The costs and effectiveness of these measures need to be regularly evaluated so successful control programs may be implemented and maintained.

## III. Programmatic Requirements for Schistosomiasis Control in Africa, Approaches to Implementation of Effective Schistosomiasis Control Programs in Africa

1. In a general review of the requirements for control programs, it was noted that development and training of manpower is a basic need. The people trained should also be prepared to work with other communicable diseases. The types of personnel needed are statistically trained epidemiologists, parasitologists, malacologists, microscopists and field technicians (to obtain sound epidemiological data) plus environmental engineers, physicians, nurses and health education personnel (to supplement the first group in the execution of control programs). There is urgent need for immediate advanced training at recognized overseas institutions of indigenous personnel in certain specialties such as malacology, epidemiology, biostatistics, environmental and sanitary engineering. Manpower reserve is inadequate in most African countries. Self sufficiency, relative to the training of indigenous personnel, should be achieved as early as possible.

2. The cost of control varies from US $0.40 to $12 per capita per annum (1973 prices). It is a mistake to try short-term efforts over large areas, since these efforts are likely to be largely wasted. At present, few countries are ready to plan realistically for a national control program. Adequate financing should be maintained for a considerable period (at least 10 years) to ensure continuity and effectiveness of the program.

3. Assistance is required for support of operational and research programs. Transport needs are considerable, but they are rarely met. Too frequently lack of personnel at all levels, shortage of drugs, chemicals, spare parts and other essential supplies impede both the continuation of on-going control programs and the implementation of new ones.

The following list indicates some of the resources needed for schistosomiasis control and research programs which might be provided at different institutional levels:

| Country | Regional | International | Bilateral |
|---|---|---|---|
| Health Infrastructure (Health Education) Training Personnel Fuel Housing | Training Institute Consultants Cooperative exchanges of results-e.g. conferences | Consultants Capital and Operational Costs (equipment, drugs, molluscides, spare parts) Transportation (roads, vehicles, boats) Training Fellowships | Technical Assistants Training (Fellowships, exchange program) Consultants Operational costs Research Programs Transport and equipment Laboratories Drugs and Molluscicides |

4. There is a potential infrastructure in many countries but there is a great need for its reinforcement.

5. It must be recognized that as cost effective technologies must take into account local conditions, it is difficult, if not impossible, to specify a generally applicable cost-effective control program. Analysis of cost-effectiveness of different measures should be part of pre-project planning in any given area.

6. In order to ensure sufficient long-term funding for schistosomiasis control, there must be integrated planning at the national level. This involves the coordination of staff from the relevant ministries: Health, Agriculture, Water and Power. This does not imply that country-wide control programs should immediately be established but rather that small pilot projects of high quality should be supported in specific areas where the disease is an important public health problem. The results obtained should be evaluated and used for planning larger scale control programs.

7. Cost-effective policies should also include social considerations. Labor-intensive control measures in areas of high unemployment or underemployment should be considered for developing countries. The "trade-off" needs to be made between meeting social concerns and achieving control effectiveness. It should also be recognized that labor intensive techniques may reduce control costs by lowering foreign exchange requirements.

8. There is a need to publicize successful results of control programs to increase the awareness of national decision-makers and local populations.

9. The use of public health legislation to support control programs should be considered.

## RECOMMENDATIONS AND CONCLUSIONS

1. It is agreed that schistosomiasis is important as a constraint in socio-economic development in Africa and that Governments should be made aware of this factor.

2. Schistosomiasis should therefore be controlled in order to maximize the benefits of development and improve the health and well-being of the people. Financing should be maintained for a long enough period to ensure continuity and effectiveness of the program.

3. Adequate provisions must be made for the introduction of measures to control schistosomiasis right from the planning stage of all water resource development projects and for these to be maintained at a high level of efficiency.

4. While existing methods of control such as mollusciciding, chemotherapy, biological control, habitat modification, safe water supply and health education can be implemented with significant degree of success, it is essential that operational research be carried out to adapt and improve the effectiveness of these methods.

5. Research should be undertaken to establish more precisely the morbid, social and economic effects of schistosomiasis infection.

6. While there is a potential infrastructure in many African countries, the need to reinforce existing facilities is very great. Adequate manpower reserve is wanting at all levels and self-sufficiency relative to trained indigenous personnel should be achieved as early as possible.

7. There is need for development of training institutions in Africa for all categories of personnel required for schistosomiasis control. However, there is urgent need for immediate advanced training of indigenous personnel in certain specialties such as malacology, epidemiology, biostatistics, environmental and sanitary engineering at recognized overseas institutions.

8. Planning of schistosomiasis control must be at the national level involving coordination among relevant Ministries of Health, Agriculture, Water and Power.

9. The most cost-effective technology and measures are prevention of transmission by simple, permanent modifications. However, when prevention is not possible, chemotherapy aimed at disease control gives rapid cost-effective results.

10. Publication of successful results of control programs should be considered to increase the awareness of decision-makers.

11. Labor-intensive control measures in areas of high unemployment or underemployment should be considered.

12. Public health legislation should be considered to include details about schistosomiasis control.

13. The US/AID can play a major and humanitarian role in the control of schistosomiasis in Africa.

14. An inventory, with special references to schistosomiasis for each country in Africa where this disease is endemic (i.e. almost all) would be most useful for the planning of assistance programs and for broad evaluation.

## ADDENDUM

Prepared by the Rapporteur

## I. CONTROL PROGRAM NEEDS

Control measures against schistosomiasis must be based on a full appreciation of these factors:

1. The epidemiologic status of the foci in terms of prevalence and intensity of the disease in the population and the extent of seriousness as measured by clinical complications.
2. The vector snail foci of infection to establish distribution of the host, their breeding seasons and any seasonal variation.
3. The effects of altitude, rainfall, temperature humidity, $p^H$ (physical characteristics of the terrain in which transmission occurs).
4. It is important to establish the sources of infection through detailed mapping of the water courses and sources of domestic water, noticing points of contact with infected water, crossing and bathing points, vegetation.
5. Soil types and $p^H$ of the water in relation to soil $p^H$.
6. The presence of animal and bird schistosomiasis host snails.
7. Type of land tenure; whether people live in villages or in nucleated homesteads.
8. Beliefs and taboos of the people.
9. Level of education of the community.
10. Rural agricultural development schemes. Irrigation, dams, water and hydro-electric dams. Location and types.
11. Sewage disposal facilities.
12. The magnitude of the problem relative to other parasitic diseases.

13. Availability of resources locally and of aiding agencies (both manpower and money).

14. Human settlements - it is advisable to place settlement in areas below the dams to avoid gravity flow of human waste into dams.

15. When funds are available, the investment of preventive measures such as cement lining of canals and use of sprinklers instead of gravity in the end offsets the recurrent cost of control.

16. Logistics - transport equipment, availability of boats for control in dams, spray pumps, etc.

17. Facilities for storage of molluscicide, etc.

18. Laboratory space availability for surveys, evaluation and research.

## II. PRINCIPAL MEASURES CURRENTLY AVAILABLE

The following are the measures currently available in Schistosomiasis control:

(a) Limiting of Human Exposure to Infected Water

This is done through enclosing known transmission sites, i.e., fencing reservoirs, dams, and rivers and occasionally by eliminating transmission sites (filling in and drainage of swamps and ponds). The limitations are due to lack of equipment and cooperation of the population. The advantage is that the land becomes permanently reclaimed.

(b) Providing Safe and Convenient Water Supply

Such alternatives must meet all the population's water needs including drinking, cooking, bathing and recreational needs especially for children, conveniently situated and the population must be educated in their use. Disadvantages are if people live in nucleated homesteads the cost of the reticulation is excessive, lack of technologists, cost of initial materials and maintenance, requires the cooperation of the population. Advantages are that other waterborne diseases are controlled, and time spent drawing water can be used for something else.

(c) Prevention of Contamination of Water by Infected Individuals

These will involve the provision of suitable sanitary facilities and the education of the population in their use. Disadvantages are the taboos and beliefs of the people, and the lack of technology, requires cooperation of the population. The advantage is simultaneous control of other diseases by this method.

(d) Mass Treatment Chemotherapy

The limitations are:

--the lack of infrastructure to administer the drugs,

--varying dosages of certain drugs with different strains of the schistosomiasis in various regions,

--the availability of one safe, cheap, accepted, easily administered drug,

--lack of cooperation of the population,

--stability of the population.

The advantages are:

--it is the most cost effective method of control of schistosomiasis,

--the reduction of prevalence to lower levels,

--individuals cured of the disease.

(e) By Attacking Molluscar Snail Intermediate Host

This can be done by:

(1) Alteration of Habitat - The habitat can be rendered hostile to the snail by engineering measures such as altering the water levels or velocity of flow or by removing aquatic vegetation, cement lining of canal and dam walls. The limitation is a lack of technology. The advantage is that prevention is better than cure.

(2) Mollusciciding - chemical

Limitations are recurrent cost and expense.

Advantages are as follows:

--it does not require population cooperation,

--it is easy to apply,

--Biological Molluscicide is still limited to Ethiopia, and awaiting results for universal application.

If these are developed they could reduce cost of control considerably.

(f) Biological Control with Plants

This is limited to the Sudan. Further research is required.

(g) Health Education Programme

The limitation is a lack of infrastructure.

(h) Siting of Villages in Rural Development Scheme

Care should be taken in settlement schemes to place these below dam areas to avoid contamination.

The use of public health legislation to support control programs should be considered.

Phased into:

1) attack phase

2) maintenance
   (a) Service
   (b) Operational research

3) integration of basic health service

Phase I: Attack Phase requires:

Epidemiology
Biologist/ecologist/malacologist
Engineer
Laboratory technician and microscopists
Statistician with assistants

Health education team
Public Health nurse and aides
Transport personnel
Field surveillance agents
Typists/account officers

Levels of Training and Manpower

Epidemiologist is a medical officer with extra public health training

Biologist has a degree in biology with extra training in malacology or environmental survey work

Diploma or degree in sanitary engineering

Laboratory technician post matriculation training
Microscopist junior certificate and on-the-job training

Statistician - diploma/degree in statistics with assistants, Form II or Junior certificate and on-the-job training

Health education - degree in public health

Public health nurses, registered nurses with extra training in public health

Transport personnel - driver's license

Field surveillance staff - Junior certificate and on-the-job training

Phase II: Maintenance requires:

Plumbers, artisans, etc.

Phase III: Integration with Basic Health Services

The number of staff will depend upon the country and the magnitude of the problem.

Finance - amounts required vary from one country to another, but can be categorized into the following headings:

Salaries
Transport
Equipment
Treatment of humans and of habitat
Health Education
Research

<u>Infrastructure</u> is dependent upon the organization of an individual country.

<u>Rational Planning</u> (see phasing)

Cost effective package depends upon:

(a) Resources of finance
(b) Availability of technology

## GROUP C: TRYPANOSOMIASIS

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# FINDINGS

## I. Magnitude of the Problem in Relation to Socio-Economic Development Potential for Africa

### A. Socio-Economic Development

Trypanosomiasis is of great socio-economic impact in tropical Africa and in the further development of the continent. The disease directly affects the health of the human population. Even more important is its indirect effect as a disease of livestock. The loss of meat production has grave consequences. An additional effect is that it decreases the availability of draw-animals and thereby decreases agricultural production. The increasing human population will need more food production, both in vegetable and animal proteins. Population pressure on existing utilized lands will lead to soil degradation and thereby further decrease the productivity of those areas.

Normal development cannot take place in vast areas of tropical Africa because of the presence of tsetse flies. This affects agriculture as well as animal husbandry. All trypanosomiasis infections and most glossina species are an important threat to the economy of the continent.

### B. Human Health and "Quality of Life"

Human sleeping sickness is a fatal disease which should be controlled wherever human settlements occur or are planned. For example, human trypanosomiasis in Zaire had been reduced to very low levels by the late 1950's. Later the abandonment of surveillance and treatment resulted in a quick build-up that reached epidemic proportions by the middle 1960's. A peak increase of at least 7,000 new cases per year occurred. Because of the long treatment and rehabilitation period, this amounted to about 25,000 known people unable to attend their normal occupations, including the production of food crops. The non-treatment of such large numbers of trypanosomiasis carriers develops in a "snow-ball effect" with tremendous potentials for spread and further increase. Gambian sleeping sickness is probably a zoonosis as suggested by recent observations made in West Africa. This disease, transmitted by palpalis group flies, is related to riverine vegetation in the classical transmission cycle. G. palpalis habitats are being increasingly described outside the riverine Biotopes. Palpalis group tsetse flies can adjust to unusual environments. In the Alego District of Kenya such an aberrent habitat for riverine tsetse flies was associated with a serious outbreak of rhodesian sleeping sickness.

In other areas, palpalis-group flies are associated with peridomestic habitats and pig styes. Similar habitats of tsetse flies can have serious impact on livestock production.

It is known that whereas Gambian sleeping sickness, usually a man-to-man transmitted disease and usually confined to well-defined foci, lends itself to successful local or regional control measures, the rhodesian variety, being a zoonosis, is far more difficult to control.

Because of its great impact on human productivity, health and well-being, the control of human trypanosomiasis should continue to be carried out under all circumstances.

C. Implications for Dependency and Self-sufficiency of Africans

Trypanosomiasis control, and in many places, glossine control, are prerequisites to any ambitious socio-economic development program in the tsetse fly belts. It is strongly stressed, however, that any new reclamation of tsetse areas should be preceded by land-use studies that include soil analyses, agricultural or/and husbandry potentials, and other aspects which will assure a successful settlement by people and cattle. Considerations should include all aspects of traditional village life such as the availability of water, firewood, areas for farming or/and cattle raising. The achievement of such a balanced environment may vary from region-to-region and may be more difficult in G. morsitans areas.

As rhodesian sleeping sickness is a zoonotic disease, cattle and other animals can be a reservoir of the human disease. Its control, especially in the wide savannah tsetse belts will, therefore, be more difficult than the control of the Gambian type. Of particular epidemiological significance in some areas are seasonally nomadic herds that may be responsible for the spread of trypanosomiasis over large areas. The domestication of certain wild animals, eland for instance, better adapted to the African environment than present domestic animals and presumably more tolerant to trypanosomiasis and other diseases, has been suggested. This approach still awaits further research and experimentation. It may prove suitable in certain areas, but there are major obstacles in other areas.

Conflicts of interest may arise from the integral maintenance of present wildlife and occupation reserves since they are at present a source of both human and of livestock trypanosomiasis.

D. Trypanosomiasis Control in Health Development Plans and in Economic Development Schemes

Trypanosomiasis presents a serious constraint in the occupation of large parts of tropical Africa. Before settlement of areas by man and his livestock, potential risks of trypanosomiasis, as well as of other diseases, should be anticipated. Control of trypanosomiasis is regarded as an essential component of successful development schemes. Furthermore, control should be planned with regard to:

(1) topography, soils and other characteristics

(2) proper balance of land usage;

(3) consent of the people and their willingness to settle the reclaimed areas; and

(4) effective management of the development scheme.

II. Current Control Measures and Their Suitability for Application in Africa

A. Specific conditions in Africa that need to be considered in developing control programs for Trypanosomiasis

African trypanosomiasis is a complex disease that affects man as well as domestic animals; it involves different *Glossina* vectors and is found in a multitude of ecological entities. Under these circumstances, the methods of control will have to be adjusted accordingly. Broadly speaking, methods of *Glossina* control are applied under the following conditions:

1. Human trypanosomiasis:

   (a) riverine biotopes (*G. palpalis*-group)

   (b) forest edge (*G. palpalis*-group)

   (c) periodomestic foci (*G. palpalis*-group)

   (d) eastern and southern savannahs (*T. rhodesiense*) carried by animals, transmitted by *G. morsitans*-group

2. Domestic animals trypanosomiasis: (*T. brucei*, *T. congolese*, *T. simiae* and *T. vivax*)

   (a) in savannah areas (*G. morsitans*-group)

   (b) riverine and forest edge vegetation (*G. palpalis*-

(c) Peridomestic (G. Palpalis-group)

3. Considerations to be taken into account with regard to control scheme are:

(a) past history of the disease in the area;

(b) local factors related to the epidemiology of the disease in the area;

(c) recent changes in the environment in human activities that would increase or decrease in disease prevalence;

(d) presence and prevalence of wildlife;

(e) precise knowledge of the bionomics of local fly populations;

(f) government policies concerning the proposed control scheme;

(g) opinion of the local inhabitants;

(h) assurance of following-up maintenance, surveillance and information

4. Preconditions to control projects should be:

(a) Is the claimed land needed and will it be economically productive after reclamation;

(b) Can the reclaimed land be consolidated through effective occupation;

(c) Can the reclaimed land be protected from fly re-invasion.

5. Manpower and trained personnel are prerequisite to the proper execution of the control scheme and later following-up operations.

6. In all cases, large scale vector control operations will benefit both humans and cattle. However, in most cases they can be justified on a cost benefit basis only for protection of cattle, as human cases are fortunately and generally too scarce to justify such operations.

Under certain circumstances, trypanosomiasis control may not be advisable, for instance when it concerns areas of poor, marginal soils, forest areas, wildlife and forest reserves; nor possible, in the absence of technology, funds, field knowledge and manpower.

B. <u>Principal Measures Currently Available for the Control of Trypanosomiasis</u>

1. Two questions are addressed regarding present measures of trypanosomiasis control. These were:

   (a) What are their limitations--from a technical point of view, from a practical point of view?

   (b) What are their advantages?

2. The transmission of trypanosomiasis can be reduced or interrupted by acting on the vector, or by protecting humans and cattle through chemotherapy and eliminating natural wild resevoirs. This latter method will not be considered in these discussions.

3. Methods used in the control of human and livestock trypanosomiasis can be briefly summarized as follows:

   (a) Elimination of the parasite:

      (1) case finding and surveillance

      (2) treatment by chemotherapy

      (3) prophylaxis

   (b) Elimination of the vector:

      (1) application of insecticides:

         (i) contact insecticides

         (ii) residual insecticides

      (2) catches of adults: by hand, traps or other means

      (3) modification of the habitat: clearing of tree cover (total, selective, discriminative), mechanical or by hand

(4) biological control, geneical control (still in experimental stage);

(i) sterile male techniques;

(ii) release of predators or parasites

4. For practical purposes, only <u>chemotherapy</u> and <u>tsetse fly</u> control through the use of insecticides or habitat modification are to be considered.

5. Control of human trypanosomiasis through chemotherapy is based upon case finding and treatment. This can be carried out through existing health service facilities, or by mobile units connected to a central surveillance operation.

(a) <u>Diagnosis</u>:

(1) demonstration of the parasite in blood smears, lymph-node aspirate, spinal fluid or bone marrow. Also through haematocrit centrifugation, DEAE cellulose column separation technique, innoculation in laboratory animals or cultivation;

(2) through various serological or other tests, some of which may not always be reliable (IFAT, IGM, ELISA, Bone-test). The Rickman and Robson blood incubation infectivity test could be considered together with other tests, in the differential diagnosis between T. brucei and the human trypanosomes.

(b) <u>Treatment</u>:

More effective and less toxic drugs are urgently needed in the chemotherapy of both human and animal trypanosomiasis. At the present time treatment of Gambian sleeping sickness is provided by injections of Mel B. Mel W. Suramine alone or in combination or in combination with Lomidine. For rhodesian sleeping sickness, Suramin is used alone or followed by the drugs above. Some active drugs such as furazine derivatives are unfortunately no longer available.

Prophylaxis of infections by Pentamindine is no longer recommended. Problems related to chemotherapy are toxic reactions, relapses and the appearance of resistant strains. Treated patients should be reexamined every six months for a period of three years. Suramin or Mel B should be used with caution in onchocerciasis areas because of the danger of severe reactions in patients with onchocerciasis.

Drugs effective and normally used in the control of animal trypanosomiasis are quinafyramine, dimimogine, homidiam, isometamidium and to each of these drugs resistant strains have been observed. In practice, case finding is not needed in livestock because when animals are exposed to tsetse, infections are certain to occur. Therefore, it is recommended that treatment be available for susceptable livestock kept in fly belts. It is pointed out, however, that whereas large herd management makes possible adequate chemotherapeutic protection this is difficult to provide for the small herder or in areas of mixed farmers, where cattle are not centrally managed.

Migratory cattle present another problem of trypanosomiasis control by chemotherapy. Animal trypanosomiases caused by T. vivax occurs outside the tsetse belts. It is transmitted by biting flies other than Glossina. Infections with T. brucei and T. congolense only occur in tsetse fly belts. Infections with T. vivax occur both in and outside Glossina belts. They are more readil limited by chemotherapy outside Glossina belts.

Although chemotherapy is in common practice for the control of both human and livestock trypanosomiasis, it is the opinion of the group that the best long-term protection against T. Brucei and T. Congolense can be achieved only through control of the Glossina vector (with possible exception of T. vivai).

At present, the most effective means of tsets fly control is through applications of insecticides. The surface to be treated, the type of insecticide and the method of application are to be decided according to local circumstances and may vary from place-to-place. The committee expressed the view that the total eradication of tsetse flies from the African continent is technically not feasible at the present time. This is possible and has been achieved in suitable local areas, some of which are substantial in extent; e.g., South Africa, Nigeria).

6. Insecticide applications are done according to the following methods:

 (a) From the ground: application of persistent organochlorine compounds (DDT or Dieldrin), in selected areas;

 (b) From the air:

  (i) "blanket" applications of non-residual acting insecticides by fixed wing plane;

  (ii) application of residual acting insecticides in selected sites by helicopter;

  (iii) repeated "blanket" application of non-residual sprays of insecticides by fixed wing plane or by helicopter.

Selective ground or air spraying of residual insecticides is highly effective and reduces both cost of insecticide and unnecessary environmental problems but requires preliminary studies to determine the refuge habitats vital to the survival of the local fly population.

The new synthetic pyrethroids, even at extremely low dosages, have proven highly efficient contact insecticides.

Thus far, no resistance of tsetse species toward any insecticide has been demonstrated.

Cost of insecticide control of tsetse flies can be decreased by precise knowledge of location of fly habitats, proper formulation and refined methods of application.

"Residual applications of insecticides must have an effectiveness lasting longer than the maximum duration of the pupal life, thus eliminating all Glossina soon after their emergence.

Non residual applications must be repeated at intervals shorter than first Glossina larviposition period, to eliminate all female flies, before they could reproduce".

Tsetse fly control by means of sterile male techniques has not reached the stage of large scale application. This method is most efficient in low fly density populations and it is thought that it could be used to great advantage in "mopping up" operations following a contact insecticide spray that has left residual fly pockets.

It is, of course, imperative that reclaimed areas should be protected from reinvasion by natural or aritficial barriers.

What options are open to African countries in application of trypanosomiasis control measures? Consider program experience and research findings in Africa.

Because of the widely distributed, but usually confined foci of human Gambian type sleeping sickness, case finding and chemotherapy seem, under most circumstances to be the most effective means of control. This, perhaps, in combination with small scale tsetse control, would be applicable in most Gambian sleeping sickness areas. Rhodesian sleeping sickness, a zoonosis carried by several wild animals and transmitted by flies of the morsitans group, is a type of disease for which control has to be considered with the animal reservoir as the main source of infection in mind. This protection against cattle trypanosomiasis in savannah areas can be achieved by tsetse fly control through insecticide application.

## III. Programmatic Requirements for Trypanosomiasis Control in Africa

### A. Program requirements for Trypanosomiasis control in Africa

1. Manpower - Finances: Components of national trypanosomiasis capability.

   (a) Vector control organization common to medical and veterinary interest:

   (1) Field units for vector survey and the execution of control/eradication work

   (2) Field units for tsetse behavioral studies would:

   (i) examine local vector distribution as influenced by environmental factors (climate, season vegetation, day and night resting behaviour);

   (ii) monitoring fluctuations in population density and geographical distribution;

   (iii) testing of effectiveness of insecticide deposits on treated vegetation and duration of persistence.

An example of a Nigerian ground spray unit with a reclamation capacity of 1000 sq. mi./year of discriminative application to 10% of the infested area:

1. Technical staff: 3 control officers (one senior); 6 field assistants; 30 tsetse control assistants; 25 permanent laborers; 300 seasonal laborers.

2. Non-technical staff: 3 clerical; 1 workshop superintendent (mechanical); 2 mechanics, 1 storekeeper; 2 watchmen.

3. Operational equipment: 6 lorries; 6 landrovers; 6 tractors and trailers; 3 water tanks; 85 knapsack spray pumps.

4. Materials: 15 T. DDT 75% W..

Such a unit works on reclamation from November to April inclusive and the operational cost per square mile is of the order of $1.7/ha. It can handle 1000 sq.mi. of average savannah infestation. Cost fluctuates enormously with terrain and degree of infestation. The approximate percent breakdown of cost is as follows:

| | | |
|---|---|---|
| Personnel | 42% | |
| Allowances | 25% | |
| Plant | 10% | |
| Insecticide | 5% | (if DDT) |
| | 12% | (if Dieldrin) |
| Other supplies | 10% | (fule, spare parts, etc.) |

(b) Animal trypanosomiasis campaign organization:

(1) therapy and prophylasis carried out by multidisciplinary local veterinary service, with the advice of the national organization.

(2) National field survey unit to study:

(i) incidence of infection in animals presented for treatment.

(ii) incidence of drug resistance at treatment points in the field; possible occurence of non-resistance to alternative compounds.

(c) Human trypanosomiasis unit:

(1) field units for surveillance of cases and early treatment

(2) hospitilization facilities

(d) Fundamental research requiring institutional facilities to be based either at a university or at a research organization within the country or shared by several countries - links with advanced research at institutions

(e) Infrastructure:

Several agencies, universities, and other institutions established within or outside Africa can be approached for technical, advisory or other support. FAO and WHO with UNDP carry out research on trypanosomiasis epidemiology and socio-economics and cooperate with endemic countries on this. The Agency for International Development supports several development activities in Africa, training programs, rehabilitation of research facilities.

Training of technical personnel is available in some long-established tsetse fly or vector-borne research centers such as Centre Muraz in Haute-Volta, N.I.T.R, in Nigeria.

(f) Rational planning:

Decisions have to be made with regard to short-term or long-term aims and strategies. It is considered that in large scale regional schemes, aims, and strategies for at least ten years should be considered. In many cases much longer projections up to twenty years should be planned.

Cost evaluations of long-term plans may be difficult to estimate, but a proportional estimation would at least help in future appropriations. Expenditures and calculations should be accompanied by expected returns from the operations: This would include increase of manpower, agricultural production, meat and milk, and the health of future generations. Benefits may not be recognized in the first stages of operations, but may become apparent as development proceeds. Studies have shown a clear correlation between health and the socio-economic status of a country.

Few countries in Africa or other parts of the world, are able to have long-range plans. In Africa there is a severe shortage of training facilities and trained people in specialized fields. The lack of trained people is an impediment upon large scale control operations not only against trypanosomiasis but also many other diseases.

Several basic requirements are to be met for the control of trypanosomiasis at the national level. The requirements are:

(i) The gathering of information concerning the past history of the disease in areas under consideration;

(ii) accumulation of local or recorded knowledge of ancient natural foci;

(iii) changes in the environment that have occurred and other data that may indicate stable or unstable conditions in the area.

The planning of a national control project should consider the following steps in actual <u>operational planning</u>:

(i) presence, prevalence and incidence of the parasite;

(ii) distribution, bionomics, density, and seasonal variation of the vectors;

(iii) domestic and wild animal resources and their relationship to <u>glossina</u>.

Cost-benefit relation is a determining factor in control plans. One important question is whether government money should be made available only when proven economically beneficial to the country? Balance of foreign exchange can often be an overriding factor. This will likely dpepend on world market prices of major export commodities. Although human health is of great (economic) importance, it is the government which will decide upon appropriations for health services. Commitments of government funds for long-term control projects will be extremely difficult. Furthermore, even commitments may be hazardous in politically unstable countries.

Proposed project program should include cost estimations and anticipated economic returns, and a time-table of operations. Cost should include all aspects of the operation: reconnaissance, training programs, preliminary control trials in representative priority areas, equipment, transport, insecticides, tractors, protective clothing, and so on. Cost estimations of the actual full-scale control operation and long-term surveilliance, the maintenance of an eventual buffer zone, and eventual final activities should be included in the cost estimations.

The integration of control schemes may be mutually beneficial to countries willing to collaborate in the control of common trypanosomiasis problems. At an international level, support for expertise may be obtained from various agencies.

Important changes that may occur during long-term programs that would involve drastic modifications in the environment should not be overlooked. For instance, the conversion of subsistence farms into large cash crop-plantations which could transform an environment suitable for tsetse flied into a unsuitable one. Dividing a large fly-belt into sections may prove easier to control.

Another example of large-scale man-made changes in the environment are artificial lakes formed behind dams which may eliminate fly-belts by inundation, but may subsequently be responsible for the creation of new fly habitats. Another consideration in long range planning should be the eventual seasonal availability of expensive pieces of equipment, such as helicopters for spraying or reconnaissance operations from other projects in the same general area.

## IV. Approaches to Implementation of Effective Trypanosomiasis Control Programs in Africa

The strengthening of national capabilities to cope with trypanosomiasis control is of primordial importance. The lack of job security is a serious constraint to the recruitment and training of technical personnel. It is, therefore, proposed that such personnel be statutorily attached to a permanent service, such as the veterinary service. Normal salary increments and statutory promotions should be encouraged that careers will not suffer in short-term detachment to tsetse work.

National trypanosomiasis control programs benefit from bilaterial collaboration or from support from international agencies such as WHO, FAO, AUO, UNDP, or from special funds from various donor countries.

## CONCLUSIONS

The group noted the existence of human and animal trypanosomiasis in most areas of Africa, south of the Sahara.

The presence of these diseases is a formidable constraint to health and to the economy in many African countries. In some parts of the continent, an epidemic situation is developing. Focal resurgence of the disease in man has been reported from widely separated areas and increasing movement of people enhances the risks of its spread.

Human trypanosomiasis and the threat of human trypanosomiasis in otherwise potentially productive areas, decreases agricultural production. Also, veterinary trypanosomiasis results in loss of meat, milk, manure and animal labor. The consequences of the disease limits food production at a time when human populations and food requirements are increasing.

Until the developing countries in Africa have completed the organization of effective control of the disease, and until they have the requisite trained personnel and funds, the help of international and bilateral agencies will be required to support these goals.

The meeting, therefore, urges the following line of action:

## RECOMMENDATIONS

1. Since control of trypanosomiasis can only be achieved with adequate organized units at the national level, special consideration should be given to developing national experts in the fields of case detection and control, and vector surveillance and control as well as to create or improve relevant infrastructure facilities.

2. Increased support must be given to those aspects of research which may lead to the improvement of existing control methods and the development of new ones.

3. It is recommended that careful consideration in all agricultural development programs be given to essential technical and technological requirements for control of trypanosomiasis and other major diseases which are constraints in target development areas.

4. Long-term support from funding agencies is required to develop effective tsetse and trypanosomiasis control

programs, organization, research and training; therefore it is recommended that funding agencies consider ten years or longer, support packages for individual programs.

5. Trypanosomiasis prevention and control methods in current use are based on very few effective drugs and insecticides. It is therefore essential to: (a) secure a continuous availability of these few drugs and insecticides to countries in trypanosomiasis endemic areas; and (b) give great priority to research for development of alternative chemotherapeutic compounds and insecticides.

## THE SUMMARY OF THE CONFERENCE

-- By Dr. E.A. Smith --

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Mr. Chairman, colleagues, distinguished ladies and gentlemen. It gives me great pleasure to be asked to give a summary of this very important, stimulating, challenging and interesting conference.

The conference was organized and convened by the African-American Scholars Council which we are all now familiar with, in cooperation with the National Medical Association and with the support of the Agency for International Development of the United States of America.

This conference was a working conference on programmatic and research strategy for the control of three major endemic diseases in Africa -- onchocerciasis, schistosomiasis and trypanosomiasis. It was attended by 50 experts, 11 of these experts being Africans. Some international agencies including the World Health Organization and the Agency for International Development of the United States of America were represented. There were many observers.

The primary purpose of the conference was to assist the Agency for International Development to develop strategies for "Research on operational problems for the control of selected tropical diseases which critically impede social and economic development in Africa and programmatic assistance to African governments in planning and implementation of endemic disease control programs in Africa". An additional purpose was to share the findings with national governments and other international agencies for use as necessary.

It is not necessary to recapitulate the recommendations and findings of each working group, because they have been ably presented and discussed. Consequently, I will attempt to highlight only a few of the recommendations and findings:

1. It is agreed that these diseases are important as constraints to socio-economic development in Africa.

2. There is need for control of all three diseases.

3. There is need for health education at all levels.

4. There is need for training of personnel, development and expansion of infrastructure.

5. There is need to improve the technology in chemotherapy, vector control and immunology. Emphasis should, therefore, be placed on research for the development of technology in these areas and sociological factors.

6. The disease should not be treated in isolation but integrated within developmental projects with coordination of all concerned.

BACKGROUND PAPER

# PROGRAMMATIC AND RESEARCH STRATEGY FOR THE CONTROL OF MAJOR ENDEMIC DISEASES IN AFRICA

Prepared By

DR. FRANK L. LAMBRECHT

## I. Background Information

One of the major constraints in socio-economic development and the improvement in quality of life in African countries is related to endemic diseases. Diseases not only cause human misery and suffering, but also result in decreased productivity thereby aggravating disease conditions. Malnutrition, often associated with failure of agricultural production, is a part of a vicious cycle in which the populations at risk not only become more susceptible to endemic and communicable diseases, but also tolerate such illnesses poorly. The latter is manifested by high mortality and intractible morbidity especially in infants and pre-school children.

Climatic conditions of high rainfall and temperature in tropical and subtropical parts of Africa create ideal conditions for breeding of certain insect vectors of the diseases and the survival of disease organisms. In addition, socio-economic development schemes which rely on water resources development (i.e., irrigation dams, "man-made" lakes, etc.) also provide favorable conditions for certain of the vectors with resultant increased incidence and/or prevalence of the diseases, expressed in terms such as "man-made" malaria, "man-made" schistosomiasis, etc.

Onchocerciasis ("River-Blindness"), Schistosomiasis ("Bilharziasi Trypanosomiasis ("Sleeping-sickness"), and Malaria are among the most prevalent of these debilitating endemic diseases in Africa. The effects from these diseases are notable in the rural areas due to incidence and prevalence of the diseases, plus the fact that their presence often affects the development and/or utilization of the most fertile lands. Since the obligatory intermediate host vectors for these four diseases require surface water environments during some stage of their development, any development scheme which is related to the utilization of surface water resources in tropical Africa is apt to encounter severe health constraints. In summary, the following may be operating as constraints to improving the quality of life of populations at risk from tropical endemic diseases in Africa:

1. The direct effect of these diseases on individuals in terms of morbidity and mortality, which leads both to human misery and decreased productivity.

2. The indirect effect of these diseases which serve as serious constraints to development by causing fertile lands to lie fallow--leading to marked decrease in potential economic development and productivity--through either aggravation or potential threat of aggravation of the health problems.

## II. Specific Problem Areas

This section will be devoted to a brief discussion of specific problem areas related to the control of three major endemic diseases in Africa: Onchocerciasis, Schistosomiasis, and Trypanosomiasis.

### A. The Diseases - (Magnitude)

#### 1. Onchocerciasis ("River-Blindness")

This is a form of filiariasis which has been estimated to affect one-million Africans. Although the disease has been reported in the mountain regions of East Africa and certain parts of the Congo forest, its most serious effects and highest prevalence by far is found in the Volta River Basin area of West Africa. In this area, of an estimated population of ten-million people at risk, more than 70,000 individuals are reported to be suffering from economic blindness. This disease is transmitted from man-to-man by an obligatory intermediate vector, a female "black fly" of the genus Simulium. Since the "black fly" adult habitat and the larval stages are associated with flowing streams or rivers, the disease is commonly referred to as "river blindness".

Although Onchocerciasis is generally not a fatal disease, the sometimes severe itching and other symptoms, such as elephantiasis, and frequent associated blindness has been reported to often lead to suicides. In its most severe stages, larvae of the parasites penetrate the anterior chamber of the eye and ultimately result in blindness. In endemic areas of the disease, practically all of the population are carriers of the disease. In hyperendemic areas the majority of the population will suffer some form of eye problem, with 10% of the population and 20% of the adult male population suffering frank blindness.

#### 2. Schistosomiasis

This is usually a chronic debilitating disease in humans in Africa, caused by two major species of

Schistosoma, S.haematobium and S. mansoni. The most common species associated with the disease in Africa is Schistosoma hematobium. This latter form of the disease affects the genito-urinary system and bladder whereas the other species affect the liver and the gastro-intestinal system. The adult worms reside in the mesenteric and pelvic blood vessels and lay eggs, which are stored in the liver and other viscera or excreted in feces and urine. The eggs remaining in the body cause tissue damage due to reactive inflammatory changes, whereas excreted eggs enter the life cycle of the parasite, i.e., egg--miracidium--snail--cercariae--man. The cercariae, capable of penetrating the unbroken human skin, develop into adult worms once inside the human host.

It has been estimated that 200 to 250 million people are affected by disease, with approximately one-third of these in Africa. In many African countries the infection rate among school age children may be as high as 60-70%. Because of its chronicity and lack of effective treatment of the disease, the majority of these children are doomed to life-long morbidity and debility from the disease.

African countries with the highest reported prevalence of the disease are Mali, Nigeria, Zaire, Swaziland, Rwanda, Burundi, Uganda, Malawi, and Zambia. The disease prevalence is reported as low or nil in South Africa, Botswana, Lesotho, and Rhodesia. The disease must be considered as a great risk in every project associated with creation of new bodies of water, such as irrigation, hydroelectric dams, ponds and lakes for fish and recreation; flood plain and swamp irrigation for rice cultivation, and so on.

3. Trypanosomiasis ("Sleeping-Sickness")

African sleeping sickness is transmitted by an obligatory intermediate vector species, the tsetse fly, and is endemic in most parts of tropical Africa. The disease is known in two forms: one form, caused by Trypanosoma gambiense and transmitted from man to man by tsetse flies belonging to the Glossina palpalis group, is a chronic but eventual fatal disease; the other form, caused by T.rhodesiense and transmitted from wild animals to man by tsetse flies of the G.morsitans group, is an acute disease that may result in death in a matter of months or even weeks. The chronic type is by far the most common. On the other hand, due to the fact that certain wildlife serve as a natural reservoir of the causative agent for the acute form of the disease, the control of the acute type is even more complex than for the chronic type.

Although the true prevalence of the disease is not known, it is estimated that of the 50 million Africans at risk from the disease the infection rate has been estimated at from 1 to 2-1/2%. It has also been estimated that in Zaire alone approximately 25,000 are affected. The fact that tsetse flies transmit both the human and livestock forms of the disease has great significance for the control of the disease, as well as socio-economic implications. Thus eradication of the common vector affects the incidence and prevalence of the disease in humans and as well as in livestock in most circumstances.

B. Socio-economic Factors

1. Onchocerciasis

From a socio-economic standpoint, the effects of the disease are very serious, particularly in hyperendemic areas. Affected families are more poverty stricken than others due to the inability of the head of the household or adult male to farm. Villages with high prevalence of the disease are likewise poorer than other unaffected villages. Onchocerciasis causes populations to resettle away from the riverine areas and, as a consequence, much fertile land goes uncultivated. This latter situation results in tremendous economic loss due to unproductivity of the people and the land. Added to the above is untold human misery and suffering.

2. Schistosomiasis

Schistosomiasis exacts a significant toll on the affected populations, both in human misery and sufferings, and in decreased productivity. It has been estimated that the work capacity is reduced by 15-18% in adults with mild infections and 70-80% in adults with severe infections. Due to the lack of cost-effective control measures in general, attempts at eradication and/or adequate control of the disease are more costly than most countries can afford. As the disease is a chronic and debilitating one which affects primarily the rural poor, the disease is generally regarded as being of insignificant economic consequence, particularly in countries where there are labor surplus markets. But in view of the widespread of the disease and the many thousands of infected people in Africa, the resultant economic issues must be considered as being tremendous.

C. Infrastructure Problems

There are several infrastructure and/or program support problems in the control of the diseases, some of the most prominent being the following:

1. Manpower

There is both a shortage of all types of trained manpower and budgeted positions by African Governments to carry out endemic disease control programs. There are also only a few centers for training of the majority of workers required to operate control programs, as well as stipends available to support such training. Due to the rather bleak outlook for employment in the field of endemic disease programs, there has been very little interest demonstrated by health personnel to become trained and go into this line of work. The control programs require such categories of trained personnel as epidemiologists, vector control personnel, health educators, public health physicians, public health nurses, parasitologists, entomologists, laboratory technicians, environmental/sanitary engineers, and water engineers. All of these are in short supply. Training programs with appropriate curricula for training of necessary manpower must be established.

2. Program Planning/Management

In Africa organized and effectively functioning endemic disease control programs are often sporadic and discontinued. Too often inter-ministerial collaboration in planning development schemes or programs are lacking. Few, if any, plans are considered to take care of the adverse health impact of development programs. Rarely is an adequate health component built into the development plan that would provide health services to the populations involved and prevent the worsening of certain health problems resulting from the development scheme. In addition, the lack of an organized and adequately staffed control program will not only prevent problem identification, but will also preclude any effective campaign against the diseases. The control programs should be organized to apply suitable and available technology/control measures in such areas as vector control, treatment of disease, health education, environmental health, and water engineering. An effective control program requires appropriate supervision at all levels, logistics support, and management support services for the program. This includes budgeting and training of staff.

D. Technology

We do not yet have cost effective means nor appropriate technology to eradicate the foregoing major endemic diseases in Africa. Often there is not sufficient coordinating effort for effective control of these diseases. For instance better control of schistosomiasis could result by better packaging and application of existing control measures. Environmental sanitation, snail control through molluscicding and engineering measures, chemotherapy measures, and health education are suitable and well acceptable measures for schistosomiasis control. Control measures for onchocerciasis and trypanosomiasis are primarily those related to vector control. There is a great need for improved technology in the area of chemotherapy, vector control, and immunology for all of the three diseases. It is hoped that the efforts of such programs as the special WHO/TDR Program, the Edna McConnel Clark Foundation Schistosomiasis Research Program, and the work of other investigators will provide many of the answers to these problems.

III. Other Related Activities

A. WHO Special Tropical Disease Research Program

The World Health Organization is in the final planning stages of a Special Program for Research and Training in Tropical Diseases. The program will concentrate on research on six endemic tropical diseases (Schistosomiasis, Onchocerciasis/Filiariasis, African Trypanosomiasis, Malaria, Leprosy, and Leishmaniasis). The TDR Program will have, among others, two most important objectives:

(1) Development of new and better tools (technology) for control of the disease through biomedical research; and

(2) Improvement and/or strengthening the research capabilities of individuals and institutions through training and through a collaborative network of research laboratories/institutions of developed and developing countries.

Although the program is planned at a global level, it will be launched initially in Africa.

B. Schistosomiasis Research Program--Edna McConnell Clark Foundation

This private voluntary foundation has instituted a major research program on Schistosomiasis with a proposed budget of several million dollars over the next five years. Emphasis will be on research on developing technology for control in such areas as immunology, chemotherapy, sociological factors, and vector control techniques.

C. Onchocerciasis Control Project-Volta River Basin (West Africa)

This project, carried out by the World Health Organization, involves seven African countries (Benin, Ghana, Ivory Coast, Mali, Niger, Togo, and Upper Volta) in the Volta River Basin Area. The project is a multilateral supported project (IBRD, UNDP, ADB, IDA, Belgium, France, West Germany, Japan, Kuwait, Netherlands, Great Britain, and Northern Ireland).

This project is primarily concerned with Onchocerciasis control by controlling the vector through insecticide spraying. The plan is to free fertile land areas in the region of onchocerciasis transmission and resettle the freed area with rural development schemes.

IV. Specific Diseases

A. Onchocerciasis

Onchocerciasis, "river blindness", is a widespread disease that has grave socio-economic effects and causes much human suffering over large parts of tropical Africa.

The last decade has seen important international involvement to control the disease in one of its most active and large endemic areas. The Onchocerciasis Control Program in the Volta River Basin (OCP) involves seven countries; it is a multilateral supported effort executed by WHO.

The disease is caused by the filaria, *Onchocerca volvulus*, transmitted by several species of *Simulium* flies which breed in swift-running rivers and streams. The major vector is *Simulium damnosum*.

The largest, continuous endemic areas are found in a large band in West Africa stretching roughly between 15° N. and 3° N. all the way to Egypt and the Sudan and part of

Ethiopia and up north along the Egypt-Ethiopia border to reach as far north as 19° N. at the bend of the Nile River. The largest single endemic area occurs in the Volta River Basin, the site that has been chosen for the large-scale onchocerciasis control program. South of the main endemic areas, the disease is found in scattered, widely separated foci, as far south as the eastern shores of Lake Malawi at latitude 17° S. Onchocerciasis is endemic in the southern part of Yemen, in and around Taiz. It is suspected that this focus may be larger and extend north into Saudi Arabia.

It is estimated that at least 20 million people in the world are infected with Onchocerca volvulus. Of the 10 million people living in the 700,000 $km^2$ of the Volta River Basin, 70,000 are blind, mainly from onchocerciasis, while many more have serious visual impairment.

The control of onchocerciasis by chemotherapy is at present not practically feasible. Two drugs are known to be effective against O. volvulus infections. One, suramin, is considered to be the best compound available to kill adult worms. The other, diethylcarbamazine (DEC), known under the commercial name of Hetrazan, is very effective in eliminating rapidly the microfilariae from the bloodstream. Unfortunately, the side-effects of both drugs for the treatment of onchocerciasis are considerable and dangerous. Furthermore, two to four weeks of treatment are required and direct medical supervision is essential. As a result, mass treatment in the hyperendemic zone would involve serious difficulties of a medical and psychological nature.

Control of the disease is, therefore, based at present upon the use of insecticides to control the Simulium vector. It is estimated that the adult Onchocerca volvulus female worm can live up to a period of 20 years in the infected human host during which time the worm produces microfilariae. These develop into infective larvae in Simulium, following the black fly's biting the human carrier. As a result of this long life-span of the adult female worm, control of the disease based upon vector control has to be maintained during the same time span. If reports that the microfilariae of O. volvulus can be transferred transplacentally from a pregnant mother to her child are confirmed, it would further complicate the determination of incidence of new infections, and the evaluation of control program efficacy. Whether the number of such transplacental transfers is large enough to have practical significance is as yet unknown.

In order to plan control operations and to assess their effect, knowledge of the disease is required. Investigatory studies will involve a number of factors related to the definitive host (man), the parasite itself, and the intermediate host (the Simulium). A complete evaluation will require studies in parasitology, entomology, hydrology, economics, epidemiology and ecology.

Experimental transmissions have shown that O.volvulus exists in a number of regional strains each associated with a particular species or subspecies of Simulium, and that microfilariae of such geographical strains may not always develop fully in Simulium vectors in other areas. The same is true for cross-transmission experiments between Latin American O.volvulus strains and African Simulium species and vice versa.

Onchocercae infection in man produces nodules, a wide variety of skin changes and lymphatic pathology, which may lead to elephantiasis and other systemic effects. The most important effects of the disease are the lesions of the eye resulting in serious loss of vision, and blindness.

Onchocerca volvulus is believed to develop to maturity and produce microfilariae only in man-no animal reservoirs are known. Animal Onchocerca, however, are quite commonly found in the tropics in areas where the human disease is endemic.

The duration of various stages of O. volvulus in the human host are now known with exactitude. Work on experimentally infected chimpanzees has shown a prepatent interval of between 10 and 20 months. This may vary between different strains. The life span of the fecund adult female worm is estimated at about 15-20 years. The life span of microfilariae is estimated between 6 and 30 months. Again, there may be variation due to both geographical strain differences, and to immunological reactions of the host. The possibility of transplacental microfilariae transfer from infected mother to child is suspected. Research to establish this possibility is of the greatest importance, because it would change substantially the epidemiological picture and affect control measures now based on a man-vector-man type of transmission.

Simuliids or "blackflies" are the only known vectors of O. volvulus, both in Africa and in the Western Hemisphere. In Africa, human onchocerciasis is transmitted mainly by members of the Simulium damnosum complex, but in East and Central Africa species, of S. neavei complex also transmit the disease.

Formerly regarded as a fairly uniform species, S. damnosum has been found through chromosomal studies to consist of a complex of 8 species: in West Africa, S. damnosum sensu stricto, S. sirbanum, S. sudanense, and S. dieguerense are found mainly in savannah areas, while S. sanetipauli, S. saubrense and S. jahense are typical of the forest zone. S. squamosus is common in the forest and Guinea savannah zones of the Cameroon and has also been found in Upper Volta. S. damnosum is considered to be a complex of sibling species, some of which do not bite man and are, therefore, not important as vectors of onchocerciasis (see map).

The aquatic, immature stages of S. damnosum are found in a wide variety of water sources of various zones, from large rivers to small streams. Among the chief ecological factors governing the choice of habitat are adequate water velocity (range 0.70 to 1.20 in/sec.), the presence of suitable support for larvae and pupae, and often half-submerged rocks. The duration of larvae development depends on water temperature. In West Africa it takes about 8 to 10 days.

The S. damnosum complex is widely distributed in the Ethiopian zoogeographical region. The northern limit of its distribution reaches 15° N. in West Africa, and 19° N. along the Nile River in northern Sudan. The Southern limit is all the way into the southern tip of Africa at 34° S. S. damnosum is also known from Yemen. The greater part of South Africa is occupied by sibling species of S. damnosum that do not bite man and are, therefore, not considered of medical importance (see map).

Females of the species S. damnosum bite from dawn to dusk, usually outdoors and on the lower parts of the body. Population density may be seasonally synchronious or more or less constant throughout the year depending on water-levels and type of larvae support, rock or vegetation.

Biting cycles depend mainly on the temperature and humidity. High temperatures during the dry season usually result in two peaks of biting activities, one in the morning, one in the afternoon. At low temperatures during the rainy season, the biting activity is usually restricted to a single afternoon peak. Generally speaking, dispersal and biting activity occurs in the close vicinity of the river banks during the dry season, but radial dispersal is much greater during the rains or during days with dense cloud cover, and also in forested areas.

S. damnosum females have a remarkable flight range, especially when helped by wind. Distances of up to 79 km. over a period of 24 hours have been recorded for marked flies along a large river in West Africa. Even longer distances have been recorded for marked flies along a large river in West Africa. Even longer distances have been observed, possibly from migrations along rivers by wind carriage, or by step-by-step colonization via intervening breeding sites. The possibility of adult female aestivation has been considered as a means of residual occupation.

Although strongly anthropophilic in presence of man, S. damnosum will readily feed on animals when the latter are easily available. Nonanthropophilic S. damnosum races have been observed in the eastern and southern part of Africa (see map).

The longevity of S. damnosum females is unknown, but is usually expected not to exceed one month. Development of the ingested microfilariae into mature, infective larvae may be completed in six days at a temperature of 34° C., up to 12 days at lower temperatures. Rate of development is closely linked to the rate of the gonotrophic cycle, likewise dependent upon temperature. The female Simulium digests its eggs by the time the larvae are halfgrown. It takes its next blood meal soon thereafter, and having gone through a second gonotrophic cycle, it is ready for its third blood meal at the time when the O. volvulus larvae are mature and have reached the proboscis. It is, therefore, from the third feeding onwards that an infected fly may become an active vector.

Onchocerciasis transmitted by S. neavei group has a somewhat different epidemiology, because these insects include species with larvae and pupae that attach themselves to riverine crabs of the genus Potamonautes, referred to as a phoretic association. S. neavei is an important O. volvulus vector in parts of Uganda. It was also responsible for the transmission in Kenya where it was eradicated. In other areas of eastern Africa, including Ethiopia, S. woodi and certain subspecies are the most important vectors.

Flight range of S. neavei is much more limited than of S. damnosum. Most biting occurs in the forest or forest galleries, also biting occurs in more open country during cloudy days.

Other man-biting Simulium with uncertain vector potentialities, include S. dukei (Cameroon), S. albivirgulatum (Central Africa), and some other less well-known species.

Human transmission directly related to contact with the vector. The intensity of this contact depends mainly on: (a) density of the vector and of the human host; (b) bionomics of the vector, its host preference, dispersal, migration, biting activities, which may all vary at different times of the year; (c) human activities, migrations in relation to breeding sites, travel, site of habitations. Very high intakes of microfilariae may be lethal to the flies, and also impair their flight range.

Entomological methods for the assessment of factors related to transmission include: (a) biting density expressed by number of flies per man/day or man/year; (b) species composition; (c) age composition; (d) infection rates expressed in proportion of immature or mature larvae.

At present, control of onchocerciasis is based upon control of the vector. A high degree of control was achieved in Abudja and Kainji in Northern Nigeria. DDT applied to rivers as a larvicide reduced the adult S. damnosum population enough to interrupt transmission. In northern Ghana control was achieved with the use of DDT applied as a larvicide at 0.05-0.1 ppm/30 min. at weekly intervals. No evidence of resistance to DDT was observed. The latter method, at present applied in the Volta River Basin, is the application of insecticide by aircraft. For large, open rivers, light fixed-wing planes can be used, but for narrow, twisting waterways and for those overhung by forest, helicopters are preferred. The insecticide selected for OCP is a biodegradable Abate, which in suitable formulations combines high effectiveness against the larvae with very low toxicity for man.

The building of dams in onchocerciasis areas may directly influence the epidemiology of the disease. The transformation of a river with suitable Simulium breeding sites into a lake may actually eliminate their breeding places, and so may level changes in the river in the downstream portions. But level changes following the construction of a dam may also increase potential Simulium breeding sites by creating conditions that are more favorable to the survival of the larvae and pupae.

In a few cases, where breeding is restricted to short stretches of river banks, the removal of attachment sites such as trailing vegetation along the banks or instream islands, large boulders, or protruding objects, can reduce or even eliminate breeding.

One important undesirable effect following the construction of a dam is the proliferation of S. damnosum in the spillways which provide ideal breeding conditions for the immature stages of the insect. Experiments have shown that certain types of spillways can be constructed that will minimize the danger of breeding sites, such as vertical planes, or a system of sluice gates and syphons for periodic evacuation and drying.

With a Simulium vector of enormous flight range and very specialized larval habitat, the control of onchocerciasis by means of vector control would seem in most areas a major undertaking surpassing the scope and ability of small scale operations.

In areas where the vector is not S. damnosum but a Simulium with a shorter flight range and where onchocerciasis may be restricted to a relatively small area, vector control techniques adapted to local circumstances still may seem possible at community capability levels.

Because of the very long life span of the adult O. volvulus in the human host, estimated between 15 and 20 years, vector control in large scale operations has to be maintained for at least that period of time.

What is urgently needed is an effective drug that would eliminate its microfilariae productivity without serious, adverse side effects. Chemotherapy and effective techniques of early diagnosis and treatment which would prevent eye (blindness) would be of enormous socio-economic benefit.

No advances have been made over the last years regarding the treatment of onchocerciasis, either for individual cases or in mass treatment. Nor have advances been made in the methods of administering diethylcarbamazine. Because of the high incidence of unpleasant reactions to treatment with DEC, and the need for repeated administration, this drug is far from ideal.

B. Schistosomiasis

Human schistosomiasis in Africa is caused essentially by two Schistosoma species: S. mansoni and S. haematobium. A third species, S. intercalatum, first described from the Congo in 1934, is being entered increasingly from West African countries.

Schistosoma haematobium, characterized clinically by blood in the urine and by various urinary bladder symptoms, has been known to occur in Egypt and Mesopotami since earliest times, associated with the agricultural civilizations of the great river valleys. Direct evidence of the presence of the parasites in early times was furnished by the demonstration of a large number of calcified ova of the parasite in the kidneys of two Egyptian mummies of XXth dynasty (1250-1000 B.C.)

Arab colonization, trade routes, slave raiding practices and pilgrimages have contributed and have initiated a first thrust of spread. It has been suggested that the expansion of the Bantu after the 15th century was instrumental in the southward spread of the disease. Westwards, the infection has infiltrated, within living memory from Zambia into southeastern Zaire. In many regions now affected, the disease was unknown before the first quarter of the 20th century. The disease was not noted in Rhodesia and Zambia a century ago.

Comparatively little is known of the history of Schistosoma mansoni infections. It is usually assumed that the parasite was spread westward from the African Lake plateau region by population movement.

Both infections were doubtless carried into the New World with the slaves from endemic foci in East, Central and West Africa, where only S. mansoni found the suitable snail vector to become established.

Other Schistosomes that may occasionally affect man are parasitic in other mammalian hosts: S. bovis, found in cattle; S. mattheei, in domestic and wild animals in southern Africa; S. margrebowiei, common in antelopes in Central Africa; S. rodhaini, in wild rodents and carnivores in Zaire, Uganda and Kenya.

The schistosome worms, belonging to the Trematoda, have a rather complicated life-cycle that requires obligatory intermediate snail vectors to complete. The succession of stages can be summarized as follows: egg → miracidium → first generation sporocyst, second generation sporocyst (in the snail vector) → cercaria → schistosomule (vertebrate host) → adult (vertebrate host).

The development in the snail, after its penetration with the miracidae that escaped from the egg, to production of mature cercariae, requires about 4 to 5 weeks for S. mansoni, 5 to 6 weeks for S. haematobium. This varies with environmental temperatures, being shorter at 26° to 28° C., and longer at lower temperatures. Cercariae emerge daily, generally in large but variable numbers, usually as long as the life span of the snail which may be more than a year. Peak of emergence is usually between 9:30 a.m. and 2:00 p.m. for S. mansoni or S. haematobium can produce severe illness with debilitating effect on the patient with resulting loss in general manpower is now well recognized. Schistosomiasis ranks among the most important public health problems of the tropics and subtropics, it is only second to malaria in its debilitating effect on the human population.

The evaluation of the public health importance of any disease is difficult. Often the quotation of infection rates calculated upon the total population is meaningless. For instance, if the Schistosomiasis rate in a given country is said to be one percent it may not be considered of great health importance but when the rate of the infection is calculated for a single endemic area within that country, it may reach 50 percent of the inhabitants. If, in addition, this area happens to be the main producer of food crops, then this rate becomes economically significant. Furthermore, it is not always the number of infected people that projects the degree of loss of manpower. A contributing factor is the intensity of the infection which, will determine the consequent disability in social terms and which has to be translated in economic consequences. Economic loss to a disease can be expressed by: (1) mortality and disability; (2) loss of manpower through absenteeism; (3) cost of medical care; (4) cost of the disease versus cost of control.

In Tanzania, a sample study in 1972 in one cane sugar estate employing 2,300 people revealed prevalence of schistosomiasis to 84 percent on an average among the cane cutters and irrigation workers. For medical care alone, schistosomiasis cost the estate an estimated annual sum of $4,866. This would be more than the combined annual cost of a snail control scheme and treatment of new laborers and dependents, which has been estimated at $3,533.

Compared with many other parasitic diseases, little overall progress has been made in the control of schistosomiasis. This lack of accomplishment may be attributed to the lack of basic information on the occurrence and importance of the disease, lack of more efficient control procedures, failure to develop better methods of control because of limited research, slow progress in providing sanitary facilities, inadequate water management, insufficient funds and shortage of trained health as well as administrative personnel.

Schistosomiasis occurs in a multitude of epidemiological patterns due to the interaction of certain basic factors. Essentially these are a low standard of living, frequent contact with contaminated waters in the rural habitat or professional activities, population density and movement, and the density of the molluscan host.

The most fundamental factor in the transmission is human behavior. Contamination of the water is essential for transmission of schistosomiasis which can only occur as a result of the unsanitary excreta disposal habits of the people. Their behavior is partially based on ignorance and apathy, but also by the lack of sanitary facilities, proper human waste disposal, and adequate public water supply. The correction of these conditions alone would be one of the most effective and permanent methods of control of schistosomiasis. But the dependence of man on water and the necessity for frequent contact with it almost ensures that in endemic areas few in a rural community will escape infection. In many endemic areas schistosomiasis is a domestic hazard and children are at great risk of acquiring the disease at a very young age. Prevalence increases throughout childhood to reach a peak usually in the second decade of life after which a gradual decline occurs. The lowered prevalence in adults may be due to immunity either reducing egg production or the number of adult worms, or the reduction of re-infections in adults who have decreased contacts with contaminated water. The importance of contact rates with water in the prevalence of the disease and egg-output has been shown in several different studies.

An unusual type of survey in Brazil, however, showed that in a group of male adults who had moved from non-endemic to an endemic S. mansoni area, prevalence and intensity of infection rose to a peak after 15-19 years. This was believed to have been due to slowly acquired immunity rather than reduced contact with water.

Although the longevity of adult worms is uncertain, it is probably several years. From the examination of infected people who left endemic areas, S. mansoni was reported to persist for about 26 years, S. haematobium for 26 to 30 years; but these figures are probably extremes.

Intensity of infection is measured by egg counting techniques. It is found that the egg output in different age groups follows the prevalence pattern with the highest egg loads being excreted by the older children or those in the second decade of life. The comparison of the egg output of children from areas of different endemicity show a correlation between prevalence of infection and egg load.

Autopsy studies have shown that considerable numbers of adult worms may infect a carrier - over 1,500 having been found in one young patient with schistosomal cirrhosis.

Experiments with different animals suggest that between 100 and 300 eggs are produced by the female S. mansoni per day. The hatchability of the eggs may be as high as about 80 percent in both S. haematobium and S. mansoni.

With peak prevalence of infection coinciding with the 6-20 age group and the fact that this group forms a large proportion of the total population of a community, it was calculated that this age group was responsible for 73-92 percent of S. haematobium contamination in areas of Tanzania.

Schistosomiasis control includes a great range of activities and a variety of objectives. The aim may be to halt transmission, to prevent infection or to forestall the development of clinical manifestations. Less ambitious, it may aim at reducing the level of transmission, infection or morbidity. It is essential that the objective of a schistosomiasis control program be clearly defined. The objective in most cases will be determined by the epidemiology and severity of the infection, resources available for control, and the priority accorded to schistosomiasis in relation to other prevalent diseases. In many instances, the control of schistosomiasis in one area should be decided in order to prevent the spread of the disease to other (uninfected) areas. The effects of water resources development projects and irrigation schemes, and the construction of dams, are likely to increase schistosomiasis unless preventive measures are taken.

Analyses of 25 schistosomiasis control programs (by WHO, 1973) indicate that in spite of many drawbacks in methodologies and techniques, transmission of schistosomiasis can be appreciably reduced by measures now available. Cost analysis from several operating control programs show that annual costs for control vary widely from $0.04 to $12.00 per person protected. Many components must be considered in calculating cost and no generalization can therefore be drawn from these figures.

Four basic methods of control are at present practically available for the control of schistosomiasis: (1) chemotherapy; (2) snail control by molluscicides; (3) modification of the environment; (4) biological control. A fifth method, perhaps the most effective, most permanent, and materially less expensive, would be the prevention through environmental sanitation measures, public health education, and the provision of potable water supplies.

Recent developments in the chemotherapy of schistosomiasis have stimulated a resurgence of interest in drugs and increased the hope that they may play an important role in control campaigns. Most of the drugs are toxic and can only be administered under strict medical supervision. The benefit accruing from their use on the community as a whole must be balanced against the risks of adverse effects.

Although some drugs may be specifically more suitable for treatment of individual patients, only those that can be considered for mass chemotherapy are here mentioned.

In S. mansoni infections, Hycathone offers the advantage of requiring the shortest therapeutic course of any schistosomicide. The cure rate is high and there is a rapid decrease in egg output. Niridazole activity in S. mansoni infections is probably inferior to that of hycathone, but the drug can be used in young age groups with less side-effects. Lucanthone hydrochloride has been disappointing in large-scale treatment of S. mansoni infection, since gastrointestinal side effects often deter patients from completing the course of treatment.

Besides Egypt, very few countries have contemplated mass chemotherapy campaigns using antimonials.

In S. haematobium infections, the outlook for mass chemotherapy is most promising with Niridazole, particularly for children and adolescents, who tolerate the drug well. Almost equally effective and well tolerated is Metrifonate. In general, the limitations for the treatment of S. mansoni with Lucanthone also apply to the treatment of S. haematobium. Available molluscicides are now available for the control of the snail vectors of schistosomiasis. A more adequate strategy for their application must, however, be developed to obtain a maximum return for their high cost. Such a strategy may differ from one area to another and between artificial water surfaces and natural ones.

The two outstanding compounds, Niclosamide and N-tritylmorpholine, are now commercially available. In their use, the stability and toxicity of the chemical as well as the hydraulic characteristics of the watercourses to be treated are important considerations in choosing the most economical compound. Properties of presently useful molluscicides are summarized in Table 4.

Niclosamide is probably the most effective compound but it is expensive and its lethal effect on fish and other aquatic animals are serious drawbacks in some situations.

N-tritylmorpholine has the advantage of being effective at an extreme low concentration and of having limited general biocidal action. It is relatively persistent without being permanent in water. Its activity ranges from 0.1 - 0.5 mg/l. for one hour exposure, and from 0.01 - 0.05 mg/l. for 24 hour exposures.

The use of molluscicides cannot be generalized as it will depend very much upon local conditions and other factors.

Sodium pentachlorphenate and copper sulfate are still in limited use as molluscicides.

Many plants from different parts of the world have been reported to possess molluscicidal potentials. Among these, Endod (Phytolacca dodecandra) has been the compound most extensively investigated. Dried berries of endod (known also as soapberry) are widely used in Ethiopia instead of soap for washing clothes. It was observed that in natural bodies of water, endod berries caused high mortalities of snails. It also kills schistosome cercariae and miracidia at very low concentrations. Being a natural product, endod could become a cheap and effective means of controlling schistosomiasis in certain areas since, under suitable climate conditions, the plant grows rapidly and bears fruit twice a year.

Slow-release formulation for molluscicides may be a method of great value. The principle of the method is the absorption of molluscicides into a medium that will release the compound at a slow rate, ideally in toxic concentrations but not more. Several chemicals or even types of paints have shown great potentials. Among them, rubber formulations have great advantages such as long life, perhaps years, ease and safety of handling, storage and dispersion.

In habitats where snails are not easily destroyed by conventional molluscicide applications or by slow-release preparations, a bait formulation in the form of a stable toxicant pellet, attractive to and ingestible by the snail, has been investigated.

To learn the effect of molluscicides on the biota, a thorough limnological investigation is required and, because of the risk of pollution of environment, it is recommended that, whenever possible, a longitudinal study of the biota be made in conjunction with a pilot study of the control operation.

There are several possibilities for the application of biological control. It can be done by competitive exclusion by introducing of competing snail species. The greatest success in this direction has been the introduction of the large ampullarid Marisa cornuaretis against Biomphalaria glabrata into Puerto Rico from South America. Several other competitive snail species are known and are considered in experimental work or pilot projects.

Another method of biological control is by predation. Snails are eaten by a number of species of fishes and could therefore be used in snail control. Actual experiments in this type of snail control are few, however. The report concerns the freeing of snails from fish-ponds in Zaire by the introduction of Serranochromis sp.; the fish are palatable, and after consuming the snails are able to thrive on other aquatic life, so that a continuous population can be maintained. Other fish species with similar potentialities include Astatoreochromis allaudi. Snail-eating insect-larvae have also been mentioned as possible application to snail control.

Of great concern should be the fact that certain snail species, or insects, are being introduced into countries in which they are not indigenous without adequate investigation of possible harmful consequences to non-target organisms.

An example of such unfortunate introduction is the recent finding in Hong Kong of snail, Biomphalaria straminea, a major vector of S. mansoni in Brazil. How the snail was introduced from the neotropics will undoubtedly never be known; most probably it was brought over with water plants imported for aquaria.

Little is known about snail-parasites that could be used as a mears of control. The occurence of a species of Microsporidae in snail colonies has been reported.

A completely different method of control, still to be called biological, is the introduction in the snail habitate of non-human trematodes. Experiments have shown that snails infected with Echinostome species from birds cannot be super-infected with another trematodes species - a kind of competitive parasitism. It would thus seem possible to prevent snails in a given habitat to become the intermediate host of human schistosomiasis by "seeding" the habitat with bird schistosomes (Echinostoma eggs, for instance). Ingriguing as this approach may seem, there are serious practical problems which may prove insurmountable. A major problem seems the necessity of achieving a very abnormal infection rate of the antagonistic trematode species in snails of at least 70%. To achieve this many hundred of millions of eggs have to be released in relatively small ponds.

In recent years great progress has been made in the understanding of the basic immunological mechanisms operating in several pathological conditions. In schistosomiasis each stage of the parasite contains antigen that may stimulate an immune response. However, at the moment, there are no accepted serological in vitro tests that correlate with protection. At best, only very poor protection can be induced by vaccination with dead parasite antigen. Protective immunity develops only after the host has experienced a living infection, a fact that suggests that the stimulation of immunity is due to some metabolic process involving the release of protective antigens.

As indicated earlier, schistosomiasis originates from human behavior. Not only is the human carrier responsible for perpetuating the parasite's life-cycle by introducing contaminated human wastage into the vector(s)' habitat but human activities often provide the environment that supports the complete extra-human life-cycle of the parasite, and of the vector.

Being man-made, many biota now suitable for vector snails can also be prevented or modified in a way to make them unsuitable as snail habitates or to avoid the snail of becoming infested by human schistosoma.

Water surfaces that support vector snails can be mechanically modified by drainage, ponding, filling or transformed in productive farmland by controlled ditches and sluices in which snail control can be more easily and less costly carried out.

The growing of flooded rice is obviously a major potential source of human schistosomiasis infections. But experiments in the Philippines have shown that with a change in farming practice from flood rice fields to the adoption of intermittent application of water, the population of snails dropped from 200 to less than one per square meter, while the yield increased by more than 50 percent.

In Puerto Rico, engineers made changes in the water flow in two small reservoirs whereby the level of the water was made to fluctuate and to fall fast enough to strand the snails and their eggs. Fluctuations of 0.5 meter every 5 to 20 days during the snail breeding season can control populations of Biomphalaria glabrata. Automatic siphon spillways can be used to cause these fluctuations at a fairly low cost. Irrigation canals can be made virtually snail-proof by removal of vegetation and/or concrete-lined.

In developing countries extensive new road building often create a string of suitable snail habitats in borrow pits, and ungraded drainage ditches. (These, by the way are also important mosquito breeding sites). Contractors should be forced to fill such excavation and properly grade evacuation ditches.

Infected streams at a river passage should be avoided by the construction of a simple footbridge. Many health problems at the village level could be solved by relatively simple application of sanitation technique. Schistosomiasis transmission when occuring in small, confined foci can easily be avoided by proper recognition of source of infection and simple, natural control measures. Public health education should be part of community-level programs, in schools, hospitals, broadcasting, and so on.

The combination of two or more control measures results in rapid fall in incidence. Chemotherapy and snail control in a sugar plantation near Moshi, Tanzania, reduced the annual incidence among laborers from 81% to 18% and the egg output in those remaining infected. The prevalence in young children was reduced to zero. Similar results were obtained in Rhodesia where infections with S. mansoni and S. haematobium were reduced from 50% to 6% by a five-year program of molluscicidi with niclosamide and chemotherapy with hycathone.

The judicious ch ; of a combination of two or more control methods adapt to take advantage of certain local conditions, may prove not only less expensive but may very well be by far more effective than a massive "blanket" application of a single control measure. Such a refined technique, however, requires a thorough epidemiological knowledge of local (seasonal) transmission patterns.

In large irrigation and development projects, engineers should consult with experts to discuss ways by which snail breeding can be avoided before the construction starts. The cost of preventing schistosomiasis after construction is very much greater if the design has not taken the problem into consideration. Essential but inexpensive provisions include the location of settlements away from the canals and drains, and provision of domestic water and latrines that discourage use of irrigation system for these purposes.

Schistosomiasis occurs in a wide variety of ecological niches related not only to diverse snail-hosts habitats but also to different human activities and behavior. This allows for a variety of possible control techniques and combinations thereof. It also means that a single technique fitting all circumstances is not possible nor recommended. Control measures should be adapted to local conditions after thorough epidemiological investigations. Eradication should be attempted accordingly by appropriate means of vector control or chemotherapy.

Characteristic of schistosomiasis transmission in certain areas is that the source of infection may be restricted to a single contaminated stream or pond, especially in the more arid regions. Such foci can relatively easily be identified and controlled by chemotherapy or snail control.

In examining the various ways of control, it must be remembered that the disease is basically directly related to human behavior. Infections in man are acquired from contact with water contaminated by himself. Transmission can therefore be avoided by (1) preventing human waste from reaching streams and ponds through provision and use of proper latrines; (2) preventing contact with contaminated water through the provision of adequate, clean domestic piped water supply including bathing and laundry facilities. It is realized that the application of these simple but extremely effective techniques of prevention in the rural areas of developing countries may face enormous difficulties--changes in human behavior may well be more difficult to achieve than the eradication by any other techniques of schistosomiasis control.

C. Trypanosomiasis

African trypanosomiasis is a complex of diseases that affect man as well as domestic animals, involves different trypanasome species, different *Glossina* vectors and is found in a multitude of ecological entities.

The human disease, called sleeping sickness, is caused by two distinct but closely related trypanosomes, T. gambiense and T. rhodesiense. The transmission of these organisms occurs in entirely different biotopes which may, in fact, have led to biological differentiation. T. gambiense causes a chronic disease that may kill the victim in 3-4 years, is transmitted by tsetse flies of so-called Glossina palpalis-group which inhabit primarily riverine vegetation. Close contact between these flies and people sharing the same habitats has resulted in a man-to-man transmitted disease. No animal reservoir of epidemiological importance has been found.

T. rhodesiense, however, is an organism that is maintained primarily in wild ungulates and other animals. Man is an occasional victim when he intrudes into the savannah habitats where T. rhodesiense circulates among the animal hosts, transmitted by tsetse flies of the so-called Glossina morsitans-group. This type of "human" disease is therefore a zoonosis. It causes a far more acute illness which may result in death in a matter of months, even weeks.

The human mortality caused by both forms of the disease is estimated at 7,000 per year, but, in fact, may be higher.

Development of T. gambiense and T. rhodesiense in the tsetse fly takes between 15 to 21 days, dependent upon temperature, after which metacyclic trypanosomes are expulsed from the salivary glands, where they underwent their last development stage, at subsequent feedings.

Trypanosomiasis in domestic animals is caused by organisms different from the human trypanosomes and are transmitted by various Glossina species, including the palpalis and morsitans-group of tsetse. Responsible organisms are essentially T. vivax, T. congolense and T. brucei, the latter closely related to the human T. gambiense and T. rhodesiense. Transmission of these trypanosomes to livestock can occur wherever tsetse flies are present. The source of infection is from a wide variety of wild animals, themselves not affected by the parasites.

Human and livestock trypanosomiasis involves different important socio-economics, and the number of potential vector species inhabiting different types of habitats and feeding on a wide variety of animal reservoirs, makes the control of the disease a complicated exercise in ecology.

Tsetse fly belts cover more than four million square miles in tropical Africa with high risks of human and livestock infections and therefore a great constraint to the development and especially of great economic importance in mixed farming areas. The presence of tsetse flies has altered cattle distribution and, in addition to direct loss due to disease, has created overstocking problems in tsetse-free grazing areas. It compels pastoral nomads to make long seasonal migrations and causes an estimated 25 percent loss in slaughter cattle along the trade routes.

A heavy expenditure of money and effort is needed to provide the proper drug-therapy to protect livestock. The shortage or entire absence of livestock in many parts of Africa, with consequent absence of draft animals and loss of manure to help soil fertility, has a profound effect on agricultural development and productivity. It also poses a severe limit on meat production and dairy products at a time when human populations and requirements for animal protein are increasing.

The presence of fly and disease exclude the use of arable land and pasture which can only be made available for settlement and land-use after expensive control measures. It is estimated that about 20 to 25 percent of the human population in Africa and at least 30 to 40 percent of their livestock wealth is under constant risk of trypanosomiasis. Whereas the distribution of the human disease, especially the gambian type, is in most cases confined to well-defined foci, the animal disease, called "nagana" occurs in greater, dispersed areas requiring a greater effort of control.

Both female and male *Glossina* are bloodsuckers, feeding during daytime. After mating, the female produces single third-stage larvae at intervals of eleven days. The females have probably a life span in nature of between 10 to 12 weeks during which time 6 to 8 larvae are produced. Both sexes feed on an average every fourth day. In most regions where blood meals were serologically analysed it was found that tsetse feed on a wide variety of animals and that feeding habits vary from region to region and with species. There seems to be a pattern of preferences, however. For instance, *G. morsitans* derives its meals mainly from warthog, followed by various wild bovids and about 10 percent on man. *G. palpalis* was found to acquire an average of 30 to 40 percent of blood meals from man, with the rest divided between bushbuck and crocodile and other reptiles. *G. pallidipes* feeds to a very large extent on bushbuck. Feeding habits are important to the epidemiology of the human disease not only because of the proportion of feeds on man but also owing to the fact that certain animals such as bushbuck, duiker and reedbuck have been found frequently to carry T. rhodesiense and are, therefore, of primary concern to human sleeping sickness caused by this trypanosome.

It is obvious that with the enormous expanses of the tsetse belts, complete eradication of the insect would be such an undertaking that it is practically not feasible, even with the best methods and techniques of control. Nor, perhaps, is such an action warranted because vast expanses of tsetse-occupied territory are on marginal or unproductive soil systems, or occupied by game reserves and natural parks that are economically more desirable to maintain in their present state. Tsetse flies are the guardians of the African environment because they prevent human and livestock encroachment. Large parts of Africa should be kept that way for both socio-economic and ethic reasons.

In view of the often contradictory interests of land planning, animal husbandry, forestry, agricultural development and conservation, control measures should be considered in relation to the local tsetse problem. Control should be integrated into an overall plan for economic development and land use, due consideration being given to the local health structure, financial resources and available manpower. Probably more than any other disease, the control of trypanosomiasis is closely dependent upon the characteristics and intended use of the environment. (Figure B-7)

Trypanosomiasis can be interrupted at two points in the transmission cycle: 1) in the host by chemotherapy; 2) by eradication of the glossina vector. In the case of human rhodesian sleeping sickness and in livestock "nagana", it is conceivable that the transmission can also be controlled to a certain degree by the elimination of the major reservoir of infection, namely through the destruction of the wild animal reservoirs.

Two clinical phases are observed in human sleeping sickness: the initial infection phase when the trypanosomes circulate and multiply in the peripheral blood and the chronic phase when the organisms invade the central nervous system where they will start the process of gradual debilitation lasting several years in T. gambiense infections but causing death in a matter of weeks in T. rhodesiense infections. It is during the early blood-phase that the disease can relatively easily be cured by a number of effective drugs such as Suramin, Pentamidine, Tryparsamide, Melarsen, Arsobal, and others. The same drugs or combination of drugs are used in the late stages of the disease but doses will be higher, treatment longer and success not always assured. As all these drugs are rather toxic there is a limit to the dosages at which they can be administered.

Specific drugs are available for animal trypanosomiasis, such as Berenil, Homidium bromide, Samorin, Prothidium, Antrycide, and others.

The problem of drug resistance is a serious handicap and, because of the larger number of infections, is especially important in the treatment of animal trypanosomiasis. Trypanosome strains have been observed to retain their resistance to drugs for as many as eight passages in the tsetse fly. The risks of resistance can be reduced by the use of pairs of drugs that are known not to cause cross-resistance, for instance homidium and diminazene aceturate in the treatment of livestock.

Pentamidine was widely used in francophone Africa as a prophylactic drug that gave protection, so it seems, of three months or more following a single injection of 2 to 5 mg/kg. Because of risks of drug resistance and in the presence in an area of rhodesian sleeping sickness, the prophylactic use of this drug may be questioned.

There is clearly an urgent need for new drugs for both treatment and prophylaxis of human and bovine trypanosomiasis.

Immunological means of control through vaccination is in its early infancy with regard practical application. The newly formed International Laboratory for Research on Animal Diseases in Kenya recently reported a possible breakthrough in this direction.

Case finding and treatment has been the major base of the control of trypanosomiasis in previous Francophone areas in Africa. Other areas, especially eastern and southern Africa countries have relied more heavily on tsetse fly control, possibly because the main problems in those areas are mostly related to livestock trypanosomiasis.

Tsetse fly control can be categorized into three major methods: 1) ecological; 2) biological and 3) chemical.

Bush clearing was among the first methods employed in tsetse control after it had been discovered that the fly's habitat was closely associated to certain types of vegetation communities. Initially, the method was applied to reduce man-fly contact at river crossings and watering places. It was later extended to savannah flies habitats as a means to develop the cattle industry. As knowledge of tsetse ecology increased, more refined clearings were experimented with, called selective or discriminative. These methods aimed at rendering that part of the plant communities unsuitable for flies which had been found to be essential to the fly's survival, especially in the dry season. It is obvious that such methods depend upon a precise knowledge of the local fly's ecology and that a degree of discriminative clearing in one area may not apply equally well in another.

Bush clearing is still practiced as a means of control but not to the same extent as in the past, and is usually practiced in conjunction with other control measures.

Clearings can be done mechanically or by hand. The choice depends on available funds and equipment, and on the type of terrain.

Ruthless or barrier clearings, in which all tree-vegetation is removed, are applied to isolate an area that has been cleared of tsetse from re-investation from a nearby fly-belt, or to halt the advance of fly into new areas. The width of such a barrier has to be 500 yards or more, depending upon local conditions.

Clearings should be planned as an integral part of development of the land with high agricultural potentials or suitable grazing. In the latter case, the grazing lands are often over-stocked and over-grazed resulting in the acceleration of erosion and final destruction of the soil for human use.

Cultivation and settlement should be properly planned to ensure that the reclaimed land will remain free of tsetse.

Another method of habitat alteration in the control of tsetse in savannah country is the elimination of its major source of bloodmeals, e.g., the elimination of wildlife. The indiscriminate destruction of game with the objective of starving the fly has been discontinued in most countries. It has been observed that tsetse control operations in general tend to reduce many game species through disturbance, hunting and habitat modifications.

Among the most promising biological methods of control is the sterile male fly technique. The sterile male fly release technique has been used with particular success against the screw-worm fly. One of the advantages of this technique is that it is particularly effective and economical when the natural population is low. This suggest that it would be especially useful after the aerial application of non-persistent insecticides as a "mop up" operation. Sterility of released insects can be induced by either high energy ionizing radiation or by mutagenic chemicals. It can be achieved on the adult fly as well as in the pupae stage. To date there has been only one large scale assessment of the method with G. morsitans. After release, on an island in Lake Kariba, puparia which had been sterilized by dipping into 5 percent TEPA, 98 percent control was obtained in nine months.

Predation and parasitism may be responsible for the natural limitation of tsetse populations but are not quantitatively well documented. In areas where such limiting factors are known to be important, the use of insecticides may prove to be more harmful to the predators than to the tsetse population itself.

On the basis of current knowledge and experience, large-scale tsetse control can best be achieved by the use of insecticides. Several methods and types of insecticides are available. Here also will ecological conditions, availability of funds and equipment, and land-use have to be considered.

The organochlorine compounds have been used for tsetse control far more extensively than any other type of insecticide now available. The most commonly used are DDT and Dieldrin. So far, no evidence of the development of resistance to these insecticides has been observed in Glossina.

Applications can be made from the air either by fixed-wing aircraft or by helicopter, using residual or contact insecticides. Contact insecticides, such as pyrethrum formulations, applied by aircraft in the form of a very fine mist kill a high proportion of the adult population, 95 percent or more, at the moment of application. The operation has to be repeated at intervals so that ultimately all adults emerging from the pupae population in the soil are killed before they deposit a new generation of larvae. Applications are made indiscriminately over the whole area to be treated so that no preliminary ecological studies are necessary except before-and-after fly-densities to evaluate effectiveness of control.

Air application of residual insecticides can be restricted to those vegetation communities which have been found during preliminary studies to be critical to the tsetse fly population. A single application, repeated every three or more months, depending upon persistence of the insecticide and rainfall, may achieve a very high reduction, if not eradication of the fly.

Despite their high cost, helicopters may prove to be valuable especially in denser vegetation and against thicket habitats of such flies as G. pallipides, by forcing the insecticide suspension inside the vegetation by downward airflow created by the propeller.

Application of residual insecticides from the ground obviously do not cover the same large areas in a given time than aircraft, but it has the advantage that spraying can be done selectively in restricted critical tsetse fly habitats. In areas with long dry seasons where tsetse flies are already close to the limits of survival, and their habitats in the dry season sometimes restricted to drainage lines, the single application of residual insecticides in those refuge habitats may remain effective for long periods.

The riverine tsetse species, G. papalis-group, is dependent on vegetation at the water's edge for its feeding area and moves along the water course by frequent rests on vegetation facing the stream. Treatment of this part of the vegetation with an emulsion of a residual insecticide that remains lethal to the fly on contact for at least two months is generally sufficient to control these species and possibly achieve eradication. G. tachinoides, although essentially a riverine species, seems more resistant to dessication and can be found in peripheral small habitats. Its control is therefore more complicated.

It has been confirmed in recent years that T. rhodesiense infections occur in cattle. These animals may therefore be a ready source of human infections with this trypanosome, in addition to the "natural" T. rhodesiense reservoir in wildlife. Pastoralists are probably at greater risks to acquire the disease from their close association with this source of infection.

It is ironic that great efforts and expenditures are made to improve natural pastures, eliminate fly and natural wildlife to establish livestock that is originally totally incompatible with the African environment. Two methods have been envisioned to take advantage of wildlife that is completely adapted to available pastures and to the trypanosomes carried by the tsetse flies. The first is to cull a certain number of game from "game farms" and to sell the meat for local consumption in organized markets. Experiments have shown that game-ranching would be more economic than cattle-raising under existing conditions in most parts of the lowland savannahs. The second possibility is the domestication of suitable "wild" animals. Two species of eland (Taurotragus) and probably several species of Oryx or Addax are thought to be potentially suitable animals to replace cattle. Domesticated elands are already herded in parts of Rhodesia and Transvaal.

As with many other diseases, man himself has been responsible for creating conditions for the close man-fly contact and the expansion of trypanosomiasis.

Specific examples were found in the Alego District east of Lake Victoria in Kenya where overgrown lantana hedges (Lantana camara), overgrown "boma" vegetation surrounding compounds, and dense "sacred grove" forest patches provided ideal habitats for G. fuscipes, normally a riverine species. The fly could conveniently feed on the inhabitants only yards away. The conditions thus created were responsible for the Alego outbreak in 1964.

Near Nsukka, Eastern Nigeria, G tachinoides, normally inhabiting riverine vegetation, was found to become established and breed in villages away from watercourses by adapting to circumstances offered by hedge vegetation and pig styes. Man is rarely fed upon, however, the principal source of blood being provided by domestic pigs.

Although direct evidence was never collected, it may be that the sudden appearance of rhodesian sleeping sickness in the Bugesera region of Rwanda in the 1950's was the indirect result of an anti-warthog campaign organized by the inhabitants to protect their crops from the enormous devastations by these animals. It was thought that the shift in feeding habits of G. morsitans from their normal warthog host to the alternate human host as a result of the depletion of the warthog population, increased fly-man contacts to a degree that reached significance in the epidemiology of the human disease.

Large water impoundment projects may cause drastic changes in tsetse fly distribution and therefore that of trypanosomiasis. Lakes created by dams may inundate and destroy large tsetse fly habitats. On the other hand, the long shore line formed by the artificial lake will develop dense riverine vegetation suitable for Glossina of both the palpalis and morsitans groups.

Man-made fly belts develop when certain soils are left fallow in savannah areas after agricultural or pastoral lands are abandoned. This is usually followed by the regeneration of thornbush vegetation commonly of Acacia type which may develop in suitable savannah-like habitats. Such an event has been historically recorded in the Karagwe area of Uganda.

The impact of population mobility on the spread of trypanosomiasis in Africa is quantitatively not well documented. However, a high-risk situation was recently described in the Southern Sudan from large-scale population movement. Population movement in Africa is not a recent occurrence but is well documented in oral and written records. Pastoralists with their herds and flocks have followed patterns of seasonal movement from time immemorial, and they still do. Pilgrims have travelled long distances to holy places for many centuries. Widespread trade contacts are well documented in African history.

In addition to these migrations, which still take place today, important new population movements have developed during this century from migrant labor, mainly agricultural or people on work contracts in industries. Reports indicate, for instance, that in certain countries or parts of countries, human sleeping sickness cases are found mainly, or solely, in persons returning from contract labor in other places. The introduction of the infection may start or reactivate local endemicity if it occurs in tsetse fly belts. Other risks of infection and possible means of introduction is through workers employed on public works such as railway line, construction or road building. Other occupational hazards concern hunters, foresters, wood and honey collectors, fishermen, veterinarians, cattle drivers, national park employees, and so on. Regular examination of these people may avoid at least partially the risks not only to themselves but to the spread of the disease.

A major part of income of many countries derives from tourism related to game park, and ancillary cottage and rural industries. Tsetse fly bites are unavoidable in most of the recreation parks. The tourist should be strongly warned of the risks and advised to report any illness to a physician versed in tropical diseases.

The success of anti-trypanosomiasis control operations has been demonstrated by spectacular decrease in the number of cases detected, but it seems that in many areas the incidence of the disease has been reduced to a limit beyond which it cannot be further reduced. This type of endemicity is designated by the term "residual trypanosomiasis" or "residual foci." These can flare up in an unpredictable manner and die out equally unexpectedly. Together with migratory introduction, these residual foci seem to be a major problem in human sleeping sickness control.

The presence and incidence of trypanosomiasis, and for some trypanosome species, the identification of the flagellate, can be discovered from the dissection of tsetse flies, examination of blood smears of wild and domestic animals and from the examination of blood smears or preparations of lymph and spinal fluid of infected humans. This information will be needed if the effect on rate of transmission before and after tsetse control or chemotherapy measures is to be assessed. Other diagnostic procedures such as the raised serum IgM test and the fluorescent antibody technique are being evaluated.

The use of maps is probably more important in trypanosomiasis work than in any other disease, mainly perhaps because presence and transmission of trypanosomiasis is related to so many different (natural) environmental factors that include vegetation types, wildlife and their migrations, climatic conditions, and human settlements and migrations.

Much inter-departmental collaboration is required to avoid costly mistakes and frustrations in planning, especially when planning relates to land-use involving agriculture, livestock, forestry, economics and administration.

Fly belts overlap many international borders so that large scale tsetse control plans inevitably will require international collaboration. Exchange of training programs and intergovernmental or international technical meetings should lead to the improvement of methods and the avoidance of unnecessary duplication of effort.

Trypanosomiasis, more than any major disease in Africa, is affected by land-use and development. Before large scale control operations are decided the following questions should be considered: (1) is the land needed and will it be economically productive after reclamation; (2) can the reclaimed land be consolidated through occupation that will keep it fly free; (3) can the land be protected from fly re-invasion.

Basically, tsetse fly control by insecticide is a straghtforward exercise of the application of residual insecticide within the Glossina habitats. Dieldrin and DDT have been proven very effective and have, so far, not shown any resistance in the fly. Problems are related to the techniques of application that are most economic and effective, especially when it concerns morsitans group flies occupying vast territories. These problems vary widely as to whether the objective is to control human or animal trypanosomiasis and whether tsetse control concerns riverine flies of the palpalis group or savannah flies of the morsitans group.

In general, control of human sleeping sickness of the gambian type can be achieved at the community level possibly by a combination of case finding and treatment, and by breaking man-fly contact through vegetation clearing of river banks at contact points.

Only in few instances can rhodesian sleeping sickness of livestock nagana be controlled through small operations owing to the usually large and dispersed habitats of the savannah flies that carry these diseases, and the fact that the parasites are found in a large number of animal reservoirs.

The epidemiology of trypanosomiasis and the ecology of the tsetse vectors are extremely complex. Techniques for control are so closely dependent upon a multitude of local factors that only after a thorough examination of all factors a plan for control can be drawn.

# V. APPENDIX

A. Chart - Effective Molluscicides and their Characteristics

B. Maps

1. Distribution and Prevalence of Onchocerciasis
2. Recorded Distribution of the Chief Vectors of *O. Volvulus* in Africa
3. Geographical Distribution of *S. haematobium* and *S. japonicum*
4. Geographical Distribution of *S. mansoni*
5. Geographical Distribution of *T. gambiense*
6. Geographical Distribution of *T. rhodesiense*
7. Some principles of TSETSE control

## Figure A

REPORT OF A WHO EXPERT COMMITTEE

TABLE 4. EFFECTIVE MOLLUSCICIDES AND THEIR CHARACTERISTICS

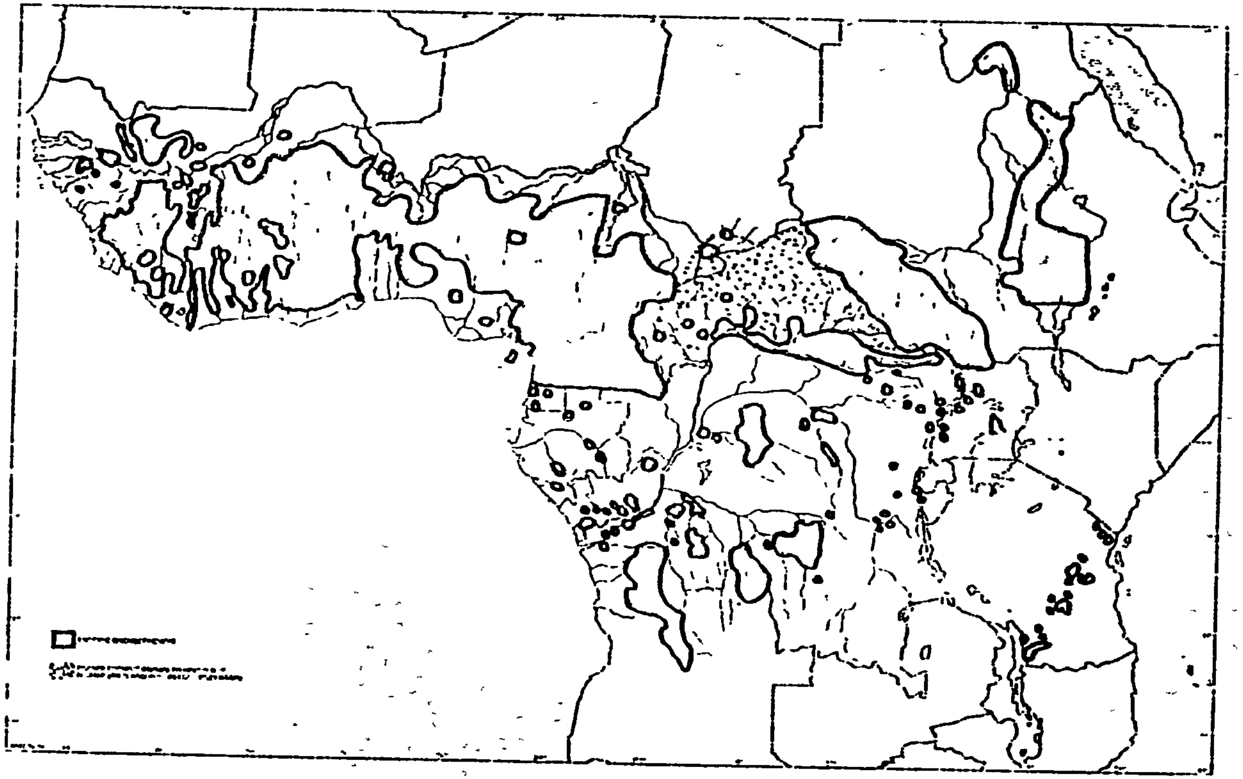
| Characteristic | Niclosamide | *N*-trityl-morpholine | NaPCP | Yurimin |
|---|---|---|---|---|
| *Active ingredient* | 2',5-dichloro-4'-nitro-salicylanilide ethanolamine salt | *N*-trityl-morpholine | sodium pentachloro-phenate | 3,5-dibromo-4-hydroxy-4'-nitroazo-benzene |
| *Physical properties* | | | | |
| Form of technical material | crystalline solid | crystalline solid | crystalline solid | crystalline solid |
| Solubility in water | 230 mg/l (pH dependent) | < 1 mg/l | 33% | very slight |
| *Toxicity* | | | | |
| Snail $LC_{90}$ (mg/l × h) [a] | 3–8 | 0.5–4 | 20–100 | 4–5 |
| Snail eggs $LC_{90}$ (mg/l × h) [a] | 2–4 | 240 | 3–30 | — |
| Cercaria $LC_{90}$ (mg/l) | 0.3 | no effect | — | — |
| Fish $LC_{50}$ (mg/l) | 0.05–0.3 ($LC_{10}$) | 2–4 | — | 0.16–0.83 ($LC_{10}$) |
| Rats, acute oral, $LD_{50}$ (mg/kg) | 5000 | 1400 | 40–250 | 186 (mice) |
| Herbicidal activity | none | none | none | none |
| *Stability* (affected by) | | | | |
| U.V. light | no | no | yes | no |
| Mud, turbidity | yes | no | no | yes |
| pH | optimum 6–8 | yes | no | slight |
| Algae, plants | no | no | no | — |
| Storage | no | no | no | — |
| *Handling qualities* | | | | |
| Safe | yes | yes | varies | yes |
| Simple | yes | yes | yes | yes |
| *Formulations* | 70% W.P.<br>25% E.C. | 16.5% E.C.<br>4% granules | 75% flakes<br>20% pellets<br>80% briquettes | 5% granules |
| *Field dosage* | | | | |
| Aquatic snails (mg/l × h) [a] | 4–8 | 1–2 | 50–80 | — |
| Amphibious snails on moist soil ($g/m^2$) | 0.2 | — | 0.4–10 | 5 |

[a] The term "mg/l × h" indicates that the figures given are the product of the concentration and the number of hours of exposure. See also footnote on p. 23.

*Niclosamide* has the advantage that, although it kills snails, snail eggs, and also schistosome cercariae, it is not toxic to man and has a limited biocidal effect. It is noncorrosive, reasonably persistent but not permanent, and is degraded by sunlight into harmless organic chemicals.

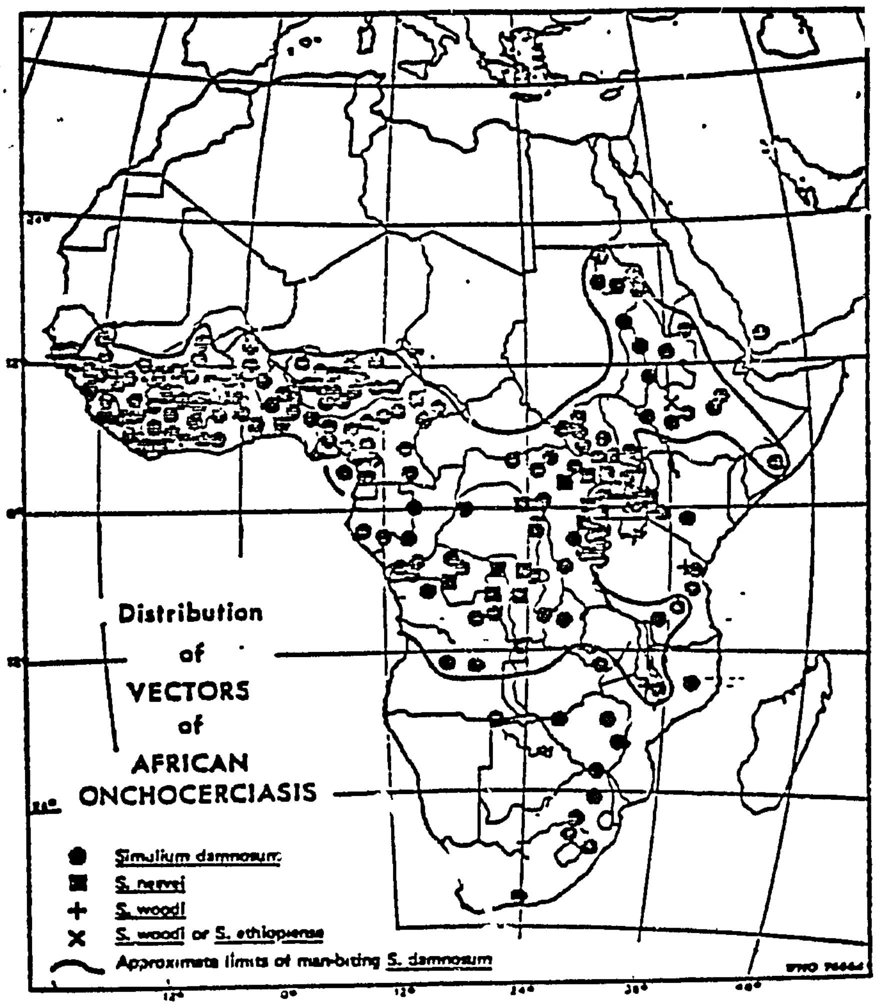
Expert Committee on Epidemiology of onchocerciasis, Geneva, 10-18 November 1975

**Figure B-1**



## Figure B-2

**FIG. 3. RECORDED DISTRIBUTION OF THE CHIEF VECTORS OF *O. VOLVULUS** IN AFRICA**




Map (revised and updated) reproduced by permission of the Trustees of the British Museum (Natural History) from: CROSSKEY, R. W. Simuliidae. In: Smith, K. G. V., ed. *Insects and other arthropods of medical importance*, London, British Museum (Natural History), 1973, p. 132.

* *S. damnosum* is considered to be a complex of sibling species (see text) and is not yet known to bite man in Yemen, where onchocerciasis occurs.

**Figure B-3**

**SCHISTOSOMIASIS**

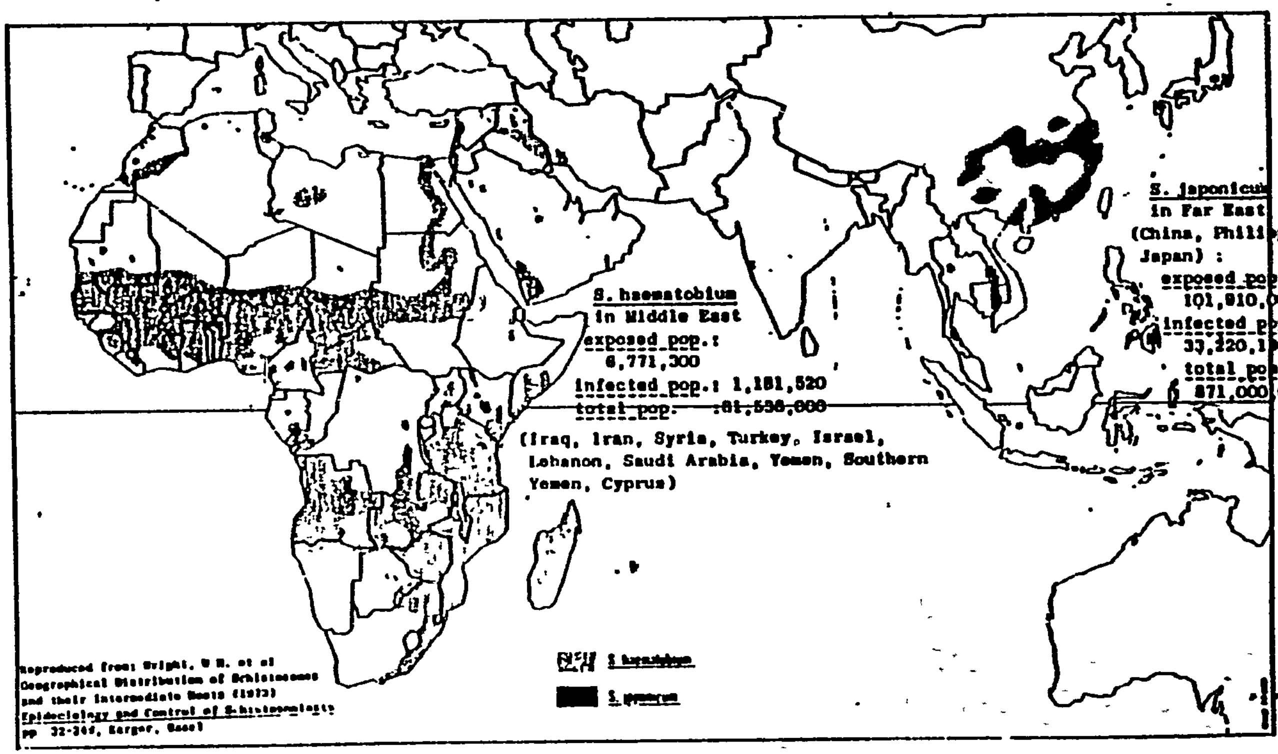


Figure B-4

SCHISTOSOMIASIS

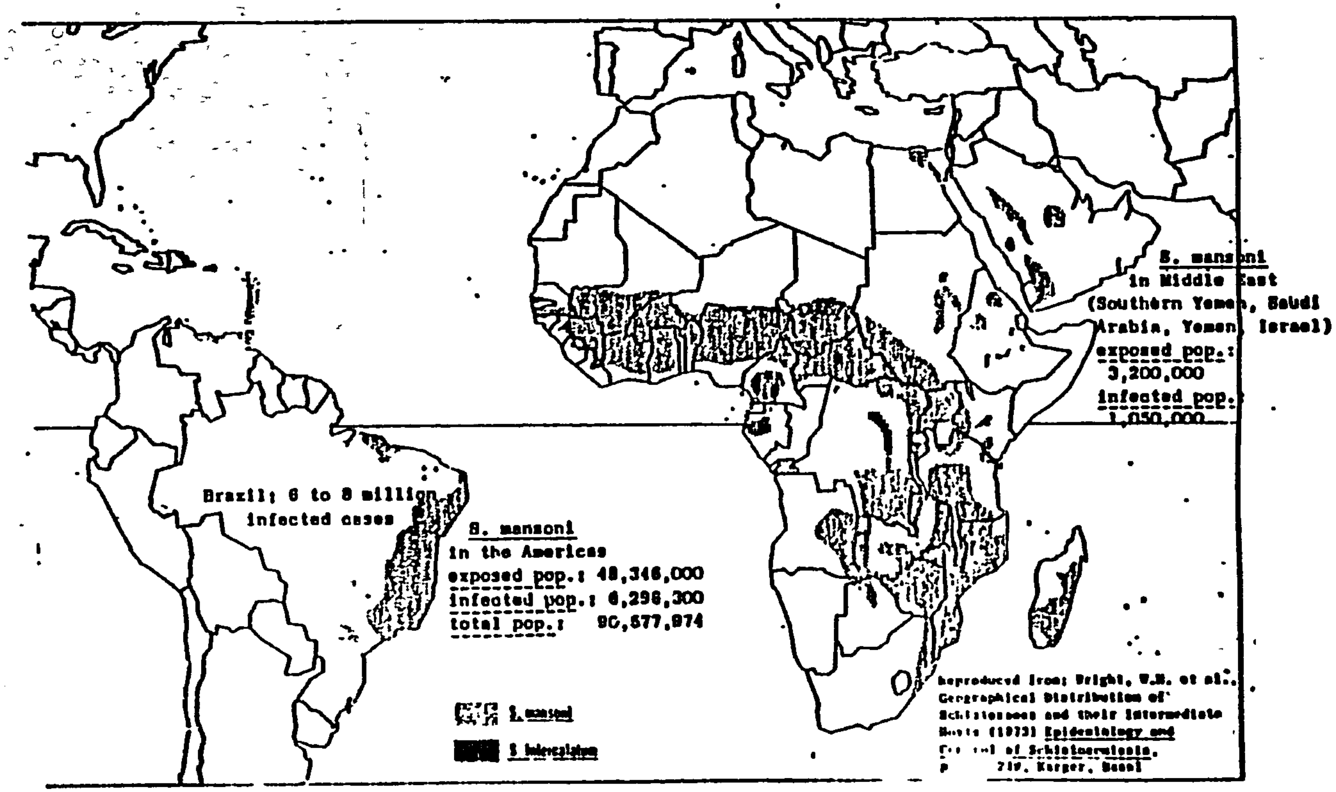


Figure B-5

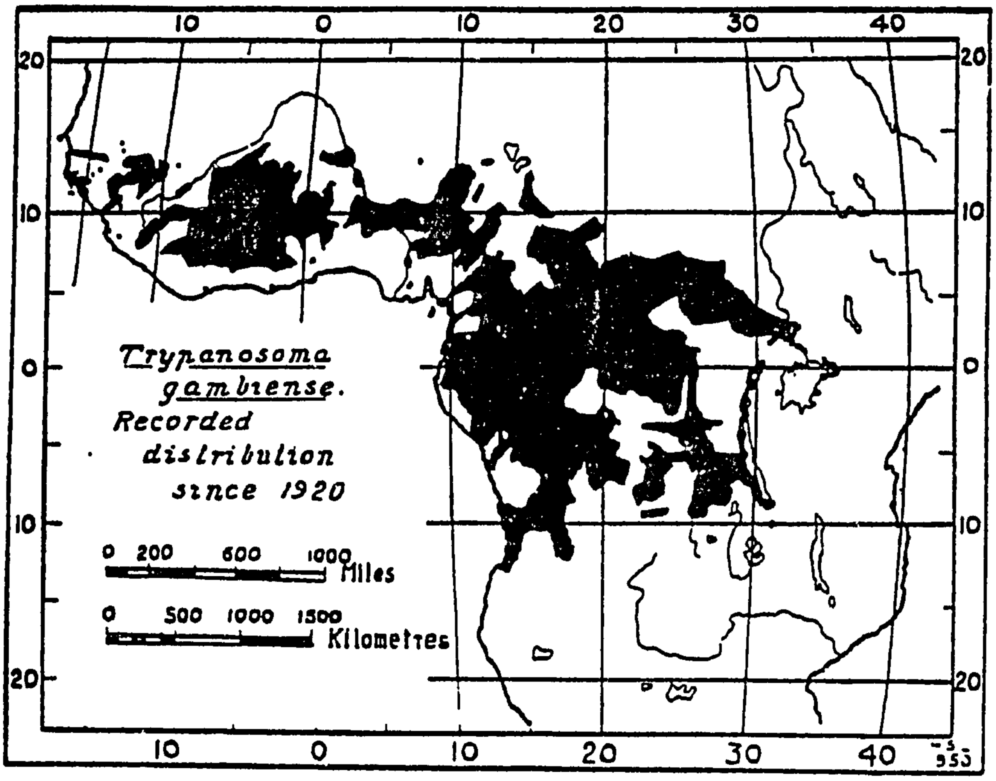

Trypanosoma gambiense. Recorded distribution since 1920
0 200 600 1000 Miles
0 500 1000 1500 Kilometres
10
0
10
20
30
40
20
10
0
10
20

Figure B-6

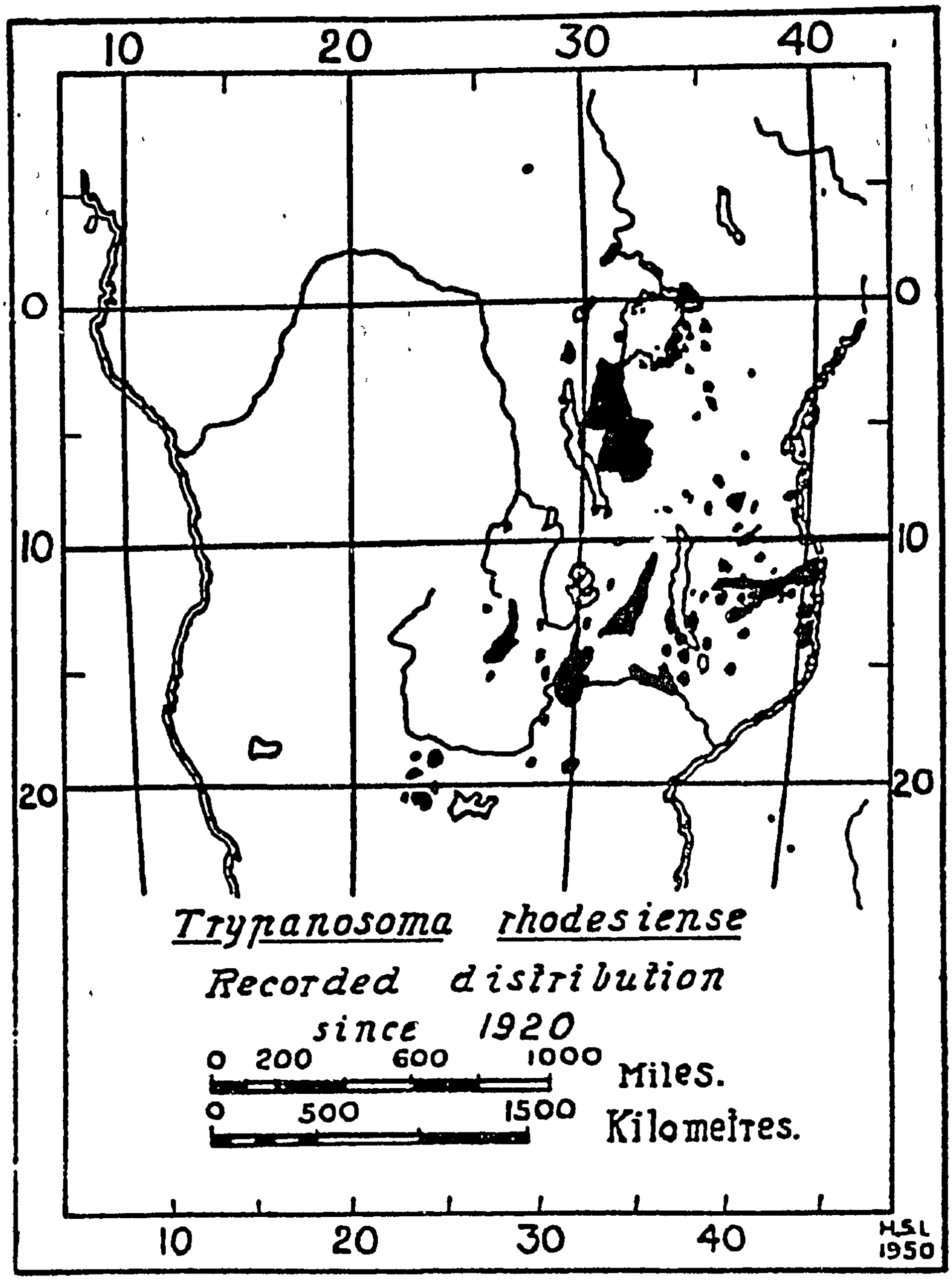

10
20
30
40
0
10
20
Trypanosoma rhodesiense
Recorded distribution
since 1920
0 200 600 1000 Miles.
0 500 1500 Kilometres.
H.S.L
1950

Figure B-7



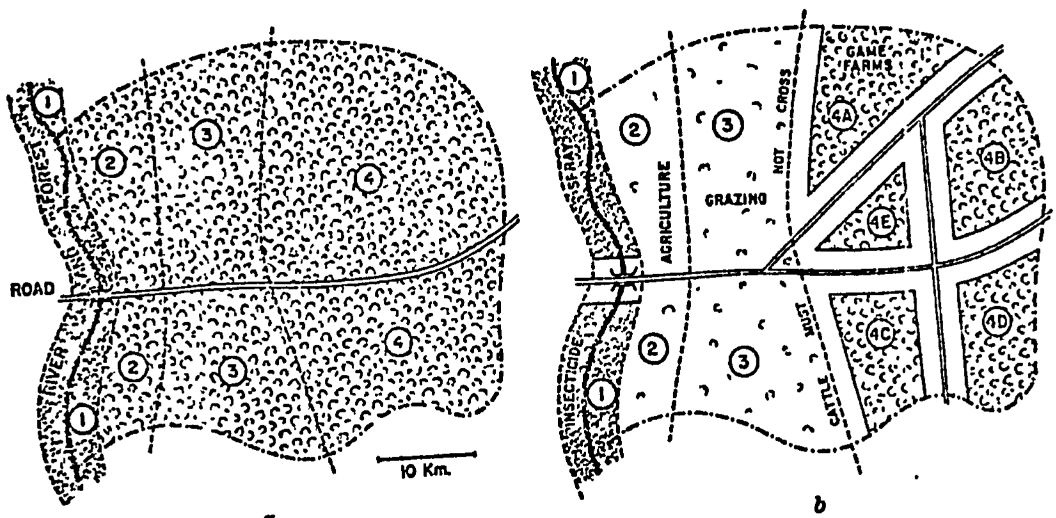



*Figure 1a*

*Hypothetical tsetse fly-belt showing: (1) forest gallery; (2) alluvial soil; (3) slope, shallow soil; (4) poor marginal land and rock.*

*Figure 1b*

*Proposed clearings and game-farming based on principles of land-use (see text) (Illustration from van den Berghe and Lambrecht, Amer. J. trop. Med. Hyg. 12 (2): 157 with the kind permission of the American Journal of Tropical Medicine and Hygiene, New Orleans, Louisiana, U.S.A.).*

# APPENDICES

- APPENDIX A -

## PROGRAMMATIC AND RESEARCH STRATEGY FOR THE CONTROL OF MAJOR ENDEMIC DISEASES IN AFRICA

-- AGENDA --

Monday, April 4

| | |
|---|---|
| 9:30-12:00 Noon | Plenary Session<br>Conference Room A |
| Co-Chairpersons: | Dr. Bernard Challenor,<br>AASC Health Sciences Committee |
| | Dr. Edward B. Cross,<br>Principal Health Advisor<br>Bureau for Africa, US/AID |
| Welcome Address: | Dr. Jose Maria Salazar Bucheli,<br>on behalf of Dr. Hector Acuna,<br>Director<br>Pan American Health Organization |
| | Dr. Constance Hilliard<br>Executive Director<br>African American Scholars Council |
| | Dr. Arthur Coleman, Representative<br>US/AID |
| Opening Remarks: | Dr. Haven North, Deputy Assistant<br>Administrator for Africa<br>US/AID |
| Presentation Papers: | Dr. Jacques Hamon, Director<br>Division of Vector Biology and Control<br>World Health Organization<br>Geneva, Switzerland<br>-- Schistosomiasis, Onchocerciasis and Trypanosomiasis in Africa and WHO Special Programme for Research and Training in Tropical Diseases |

Presentation Papers:(cont'd)

Dr. Peter Jordan, Director
Research and Control Department
Ministry of Health, St. Lucia, W.I.

-- Schistosomiasis, Research to Control

Dr. Edward B. Cross
Principal Health Advisor
Bureau for Africa
US/AID

-- "Orientation to the Working Conference"

Monday, April 4

2:00-5:30 p.m. Working Session I

"Magnitude of the Problem in Relation to Socio-Economic Development Potential of Africa"

Group A. Onchocerciasis - Conference Room A

Co-Chairpersons: Dr. Abdel Hafiz Abu Yousef
Dr. Ian S. Lindsay

Rapporteur: Dr. Everett Schieller
Assisted by Dr. Jaime Ayalde
Technical Advisory Committee

Group B. Schistosomiasis - Conference Room B

Co-Chairpersons: Dr. Emmet A. Dennis
Dr. David Scott

Rapporteur: Dr. Margaret Chuene
Assisted by
Dr. Patricia Rosenfield
Technical Advisory Committee

Group C. Trypanosomiasis

Co-Chairpersons: Dr. Thomas Odhiambo
Dr. J. Burke

Rapporteur: Mr. Frank Lambrecht
Assisted by Dr. Nels Konnerup
Technical Advisory Committee

Tuesday, April 5

9:00-12:30 p.m. — Working Session II

"Current Control Measures and their suitability for Application in Africa"

2:00-5:30 p.m. — Working Session III

"Programmatic Requirements for Endemic Disease Control Programs in Africa"

Wednesday, April 6

9:00-12:30 p.m. — Working Session IV

"Programmatic Requirements for Endemic Disease Control Programs in Africa" (continued)

2:00-5:30 p.m. — Working Session V

"Approaches to Implementation of Effective Endemic Disease Control Programs in Africa"

Thursday, April 7

9:00-10:00 a.m. — Working Session VI

Finalize Written Reports and Recommendations

2:00-5:00 p.m. — Plenary Session
Conference Room A

Co-Chairpersons: Dr. Bernard Challenor
Dr. Edward B. Cross

Panel Discussion: "Findings and Recommendations of the Working Groups"

Thursday, April 7 (continued)

General Discussion

Closing Remarks: Dr. E.H. Smith
Senior Consultant
Epidemiologist
Federal Ministry of Health

"Summary of the Conference"

Adjournment

- APPENDIX B -

## OUTLINE: WORKING GROUP SESSIONS

Working Session I - Magnitude of the Problem in Relation Socio-economic Development Potential in Africa

Objectives:

Explore the relative importance of Onchocerciasis, Schistosomiasis and Trypanosomiasis as a constraint to socio-economic development in Africa.

Clarify the Trypanosomiasis control needs relative to socio-economic development plans.

Issues for Discussion:

1. To what extent is Onchocerciasis, Schistosomiasis and Trypanosomiasis a constraint to over-all development in Africa?

   Socio-economic development
   Human health and quality of life
   Implications for dependency and self-sufficiency of Africans

2. To what extent should Onchocerciasis, Schistosomiasis and Trypanosomiasis control figure in health development plans and in economic development schemes?

Working Session II - Current Control Measures and their Suitability for Application in Africa

Objectives:

Analyze technological and non-technological constraints in the application of Onchocerciasis, Schistosomiasis, and Trypanosomiasis control measures in Africa.

Identify options for application of the current control measures under the various conditions existing in Africa.

Issues for Discussion:

1. What are specific conditions in Africa that Onchocerciasis and Schistosomiasis need to be considered in developing control programs for Trypanosomiasis?

2. What are the principal measures currently available for control of Onchocerciasis, Schistosomiasis and Trypanosomiasis? What are their limitations -- from a technological point of view, from a practical point of view? What are their advantages?

3. What options are open to African countries in application of Onchocerciasis, Schistosomiasis and Trypanosomiasis control measures? Consider program experience and research findings in Africa.

Working Sessions III and IV - Programmatic Requirements for Trypanosomiasis Control in Africa

Objectives:

To define programmatic requirements for Onchocerciasis, Schistosomiasis and Trypanosomiasis control Programs in Africa.

To assess status of programmatic resources available for Trypanosomiasis control in Africa, define main deficiencies and approaches to provision of basic requirements for long term control.

Issues for Discussion:

1. What are the program requirements for Onchocerciasis, Schistosomiasis and Trypanosomiasis control in Africa?

   Manpower - levels of training, numbers and types
   Finances
   Infrastructure - organizational and institutional development

Rational planning
Cost-effective packaging of technology and control measures

2. What is the status of programmatic resources for long-term control?

   Manpower
   Finances
   Infrastructure
   Rational planning
   Cost-effective packaging of technology

3. What approaches might be suggested to secure the resources required for long-term control:

Work Session V - Approaches to Implementation of Effective Onchocerciasis, Schistosomiasis and Trypanosomiasis control Programs in Africa

Objectives:

Identify approaches to implementation of effective Onchocerciasis, Schistosomiasis and Trypanosomiasis control programs in Africa.

Identify assistance needs and sources of program support.

Issues for Discussion:

1. What resources might be made available for these programs by African Governments, Regional Organizations, International Organizations and Assistance Agencies?

2. How might these resources be secured and coordinated?

Work Session VI

Reports and recommendations.

## - APPENDIX C -

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