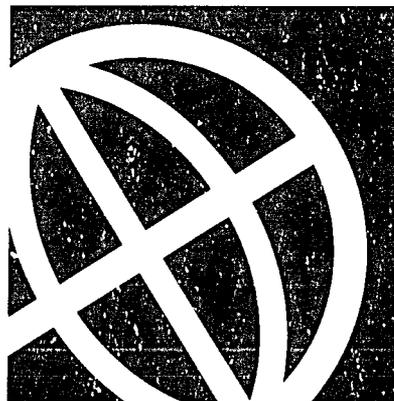
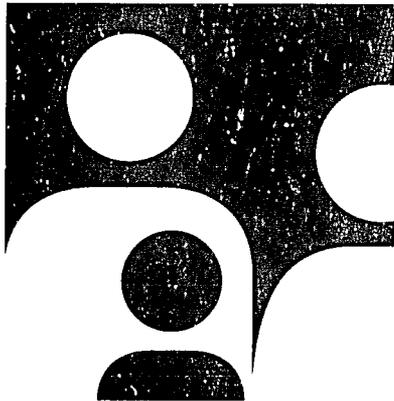
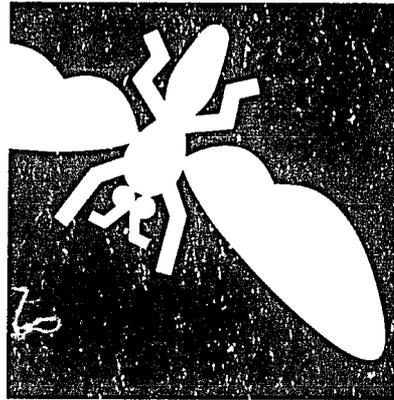
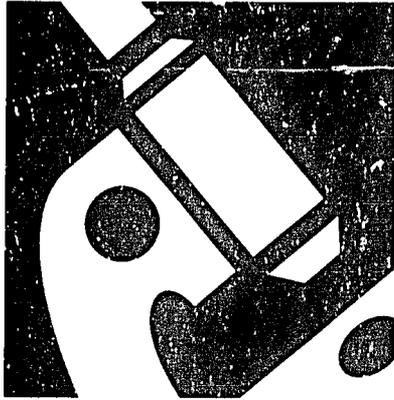


# ONCHOCERCIASIS

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VBC TROPICAL DISEASE PAPER NO. 3

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**ONCHOCERCIASIS**

**by**

**Everett L. Schiller, Sc.D.**

**August 1990**

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**VBC Tropical Disease Paper No. 3**

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**Life cycle illustrations:**  
**Cover design:**

Taina Litwak  
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*The blue square shows a black fly, which transmits onchocerciasis. The other symbols depict the essential components of vector-borne disease control: the environment, communities and research.*

**Author**

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## Executive Summary

Approximately 17.5 million people are afflicted with onchocerciasis and 340,000 are completely blind because of the disease. An estimated 78.3 million people are at risk of infection in Africa south of the Sahara to Angola, Yemen, and in smaller foci in Latin America. Although it is not life-threatening, the economic repercussions of onchocerciasis are severe because it is often the family providers who are stricken with the chronic effects of the disease. In the 1970s, WHO estimated that 10 percent or more of some heavily infected communities were "economically blind" as a result of onchocerciasis.

The disease is caused by the filaroid nematode, *Onchocerca volvulus*, which is transmitted by female black flies of the genus *Simulium*. The larval stage of the worm is picked up with the blood meal and matures to the infective stage within the fly. Development to the adult stage continues in the human host. Within a year after entering a human, the adult worms pair and mate and are eventually encased in a fibrous nodule that results from the host's immune response. Female worms produce thousands of larval worms, or microfilariae, per day and may continue to do so for more than 15 years.

The microfilariae stage elicits the onchocerciasis syndrome: blindness, lymphatic complications and various skin problems. Humans are the only reservoir for *O. volvulus*.

The disease has been controlled through chemotherapy, nodulectomy and vector control. The greatest success in onchocerciasis control has been realized with larviciding campaigns to control the vector black flies. The Onchocerciasis Control Programme (OCP) in West Africa uses larvicides with low environmental impact as the major intervention for control of the disease. It has been in operation since 1974 and currently covers virtually every river where the flies are found in 11 countries (more than 1.3 million square kilometers), serving a population of 25 million.

As a result of the efforts of the OCP, which receives \$2.5 million a year from A.I.D., there are now areas that are completely free of transmission. Fertile tracts of land that had to be abandoned due to the ravages of the disease and the flies have been resettled and cultivated. A 1984 epidemiological evaluation concluded that vector control had been successful in interrupting transmission in 90 percent of the original OCP area.

Because the adult worms of *O. volvulus* live for 10-15 years or longer and there is no safe drug that can kill them, the vector control interventions used by the OCP must be continued for at least 15

## 2

years. In addition to the obvious financial burden, this approach has promoted development of insecticide resistance in the flies.

The status of black fly control in countries surrounding the OCP area is also a problem. The flight range of a black fly may exceed 100 miles. There is understandable concern that when the OCP suspends vector control operations, the vectors will quickly reinvade the control areas, bringing new infections to areas that are now considered non-endemic.

The chemotherapeutic agent most used to date, diethylcarbamazine (DEC), produces several undesirable side effects, including severe itching. A newer, semi-synthetic compound, ivermectin, provides longer lasting control of microfilariae with fewer side effects. It can be used prophylactically to kill larvae newly introduced by black flies, but, like DEC, ivermectin does not kill adult worms.

Ivermectin is being considered as a follow-up intervention after the OCP is disbanded through a process called "devolution." New data indicate that microfilariae may return to the skin of patients within six months after successful treatment, casting serious doubt on the hope that ivermectin might be effective in interrupting transmission. Nevertheless, ivermectin represents an important tool for blindness prevention. The manufacturer, Merck, Sharp and Dohme, has made the drug available to qualified health providers at no cost. Now the challenge is the develop cost-effective ways to distribute ivermectin.

## 1. Introduction

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Onchocerciasis is a widespread plague that causes much human suffering and grave socio-economic problems over large areas of tropical Africa and Latin America. The infection in man is caused by the filarial worm *Onchocerca volvulus*, which is transmitted from person to person through the bites of female black flies of the genus *Simulium*.

The extent and severity of this disease have been recognized only during the last two decades. Onchocerciasis is considered one of the world's most formidable public health problems, afflicting about 17.5 million people, of whom one million are partially or completely blind. An estimated 85.5 million people in 35 countries live in endemic areas.

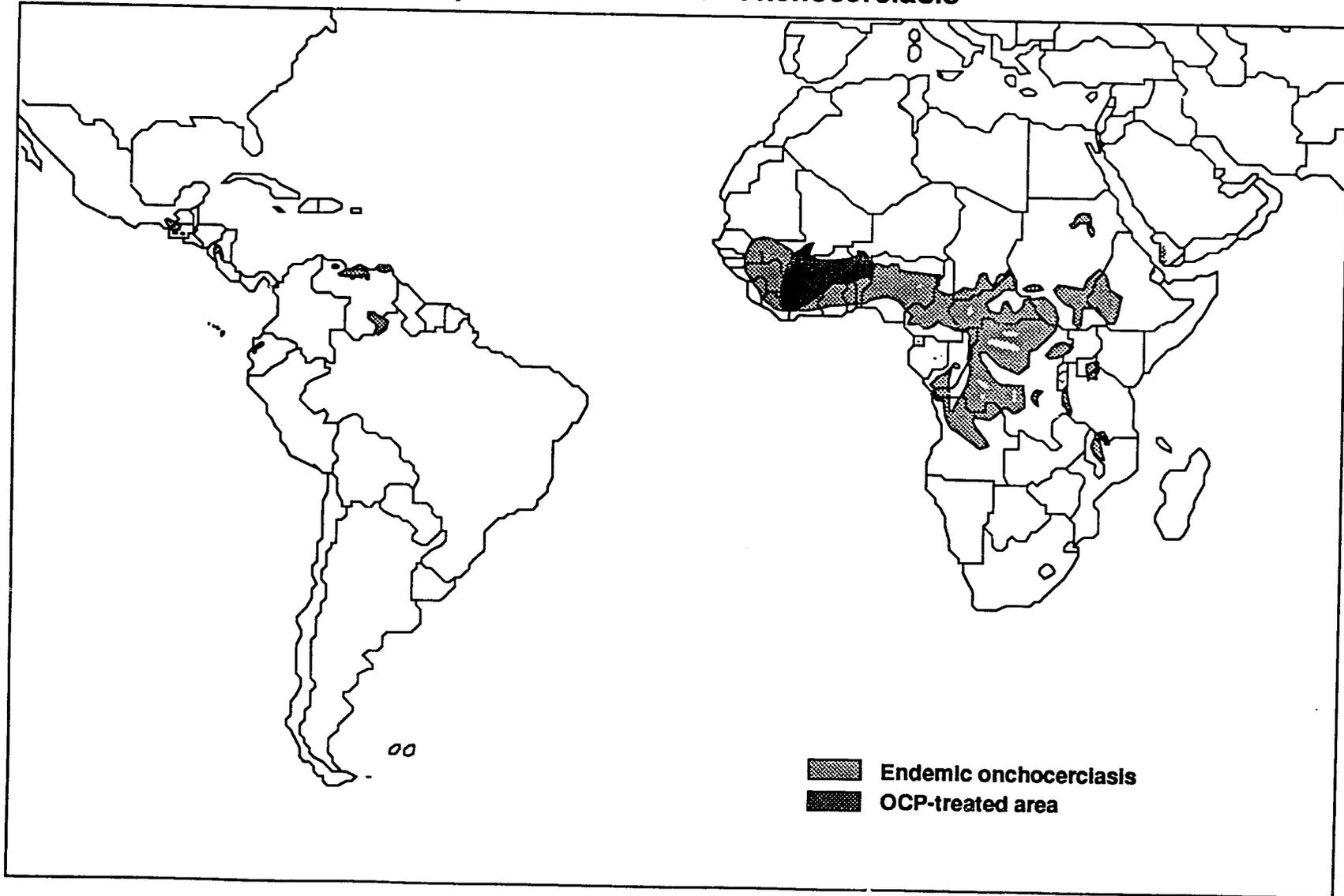
Onchocerciasis is a chronic, nonfatal filarial disease characterized by fibrous nodules, or onchocercomas, in subcutaneous tissues, particularly of the head and shoulders (the Americas) or pelvic girdle and lower extremities (Africa). The adult parasites are found in these nodules and also in deep-seated bundles lying against the bones or near joints. The female worms discharge microfilariae. In patients with severe infections, millions of microfilariae migrate through the skin, causing intense rash and itching, changes in skin pigmentation, swelling and atrophy of the skin. Persistent scratching may cause bleeding and lead to secondary infection. More advanced changes include papules, skin thickening and wrinkling, scaling and spotty depigmentation. Microfilariae frequently reach the eye, causing visual disturbances and blindness.

In some regions of West Africa, onchocerciasis is a more important cause of blindness than trachoma. The main damage to the eye is caused by calcification of dead microfilariae in eye tissue. Microfilariae may be found in organs and tissues other than skin and eyes, but their clinical significance is not yet clear.

### a. Biogeography

The geographical distribution of onchocerciasis in Latin America is sporadic, with important foci in Mexico, Guatemala and Venezuela. The disease also has been found in Colombia, Ecuador and the state of Amazonas in northern Brazil. The majority of cases are found in Africa in a wide zone extending across the continent. Roughly, the northern border of this

**Map 1. Distribution of Onchocerciasis**



*Prepared by the Vector Biology and Control Project  
Source Map: World Health Organization, 1987*

zone lies along the 15th parallel from Senegal to Ethiopia. The endemic area extends south of the equator to Angola in the west and Tanzania in the east. Localized foci exist in Sudan and Yemen.

## **b. Parasitic agent**

The parasite *Onchocerca volvulus* is a nematode belonging to the family Filaridae. Adult worms pair and mate in the human host. Each pair eventually becomes encased in a subcutaneous fibrous nodule that results from the host's immune response. Unlike most nematodes, which produce eggs, the female *Onchocerca* "gives birth" to microscopic larvae (microfilariae), producing thousands every day. The estimated yearly microfilarial production by *O. volvulus* is about one million per female. The life span of the microfilariae in the human host has been estimated at between six and 30 months.

Maturation of infective larvae into adult worms occurs in about one year. The adults can survive and continue to produce microfilariae for as long as 15 years.

Humans appear to be the only natural definitive host for *O. volvulus*. However, infections with this species have been recorded in a spider monkey and a gorilla. The chimpanzee *Pan satyrus* can be infected experimentally with *O. volvulus*, but it has not been found naturally infected.

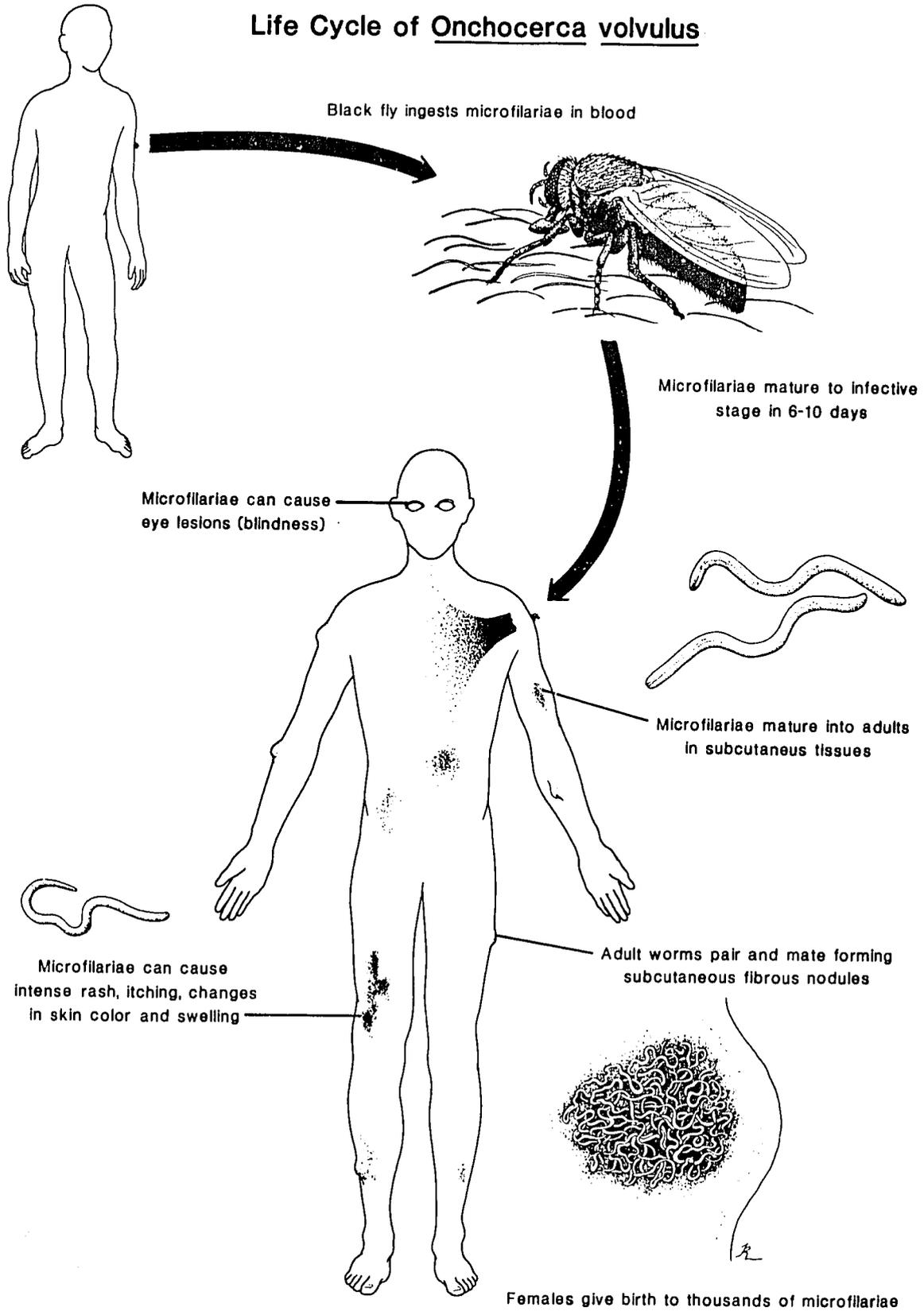
According to at least one report, it appears that congenital transmission can occur. Microfilariae were found in the skin and umbilical cords of two of 11 babies born to 10 mothers in Bawku Hospital, Ghana, who were infected with *O. volvulus*.

## **c. Vectors**

Simuliids, or black flies, are tiny, ferocious biters. They also are the only vectors of *O. volvulus*. Of the more than 1,000 species and variants of *Simulium*, relatively few are vectors of onchocerciasis, but many are serious pests because of their aggressive biting habits.

Microfilariae in the skin of an infected human are ingested when the black fly takes a blood meal as part of her reproductive cycle. It has been suggested that the microfilariae are attracted to

### Life Cycle of Onchocerca volvulus



the site of the bite by the salivary secretion of the black fly. The microfilariae mature to the infective stage within the fly, and can infect a new host when the insect takes another blood meal. Maturation in the fly can take between six to 10 days.

## 2. Distribution and Severity

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Onchocerciasis, also known as river blindness, is widely distributed in sub-Saharan Africa. An estimated 78.3 million people are at risk of infection, 17.5 million are believed to have onchocerciasis and 340,000 are blind as a result of the disease.

In Latin America, the geographical distribution of the disease is sporadic and blindness is less prevalent than in West Africa. Important foci exist in southern Mexico, Guatemala and Venezuela. The disease also occurs in Columbia and the Brazilian state of Amazonas. The first known focus of onchocerciasis in Ecuador was discovered in 1982. This finding suggests that the disease may be distributed more widely in South America than current reports indicate.

Onchocerciasis probably occurs throughout Yemen and may extend into Saudi Arabia, where more than a dozen cases of ocular and dermal onchocerciasis have been found in villages around Khamis Mushayt.

Local variations in endemicity and severity of disease have been summarized for a selected number of countries in Table 1 in the annex.

Onchocerciasis is an insidious, chronic disease that affects rural populations. It is often accepted as inevitable by people who live in impoverished endemic areas. The medical, social, economic and political implications of onchocerciasis are enormous.

### a. Disease impact

Onchocerciasis-related blindness results from decades of infection and reinfection and affects relatively few people. However, many others suffer varying degrees of visual impairment and may be "economically blind," or unable to see well enough to work. Any degree of onchocerciasis-related blindness is virtually irreversible.

There is an observed variation in blindness rates in different geographical and ecological areas. For example, onchocerciasis is much less likely to be blinding in Latin America than in Africa. Even within Africa, blindness occurs seven times more frequently in non-forest (savannah) areas than in forested areas. The reasons for these geographical differences are not well understood,

but they appear to be related to the distribution of distinct strains or biological variants.

In addition to blindness, onchocerciasis produces a number of unsightly, disfiguring skin conditions that range from depigmentation, leathery skin patches and tumor-like nodules to bizarre swelling and sagging of the flesh caused by chronic interference with lymphatic circulation. These manifestations are rarely life-threatening but can affect mobility and social acceptability. *O. volvulus* infection also reduces resistance to other diseases, reducing life expectancy among infected people by about 13 years.

## **b. Economic impact**

Onchocerciasis is a striking example of how disease can compromise the human potential for economic development. WHO estimates that 10 percent or more of some heavily infected communities may be "economically blind." In some villages in Burkina Faso and Ghana, the prevalence of blindness reaches 35 percent. Blindness of this magnitude reduces the productivity of agricultural communities below their survival level. A community loses an average of 22 productive man-years (nine years of disablement and 13 years lost due to premature death) for every blind person. One study of onchocerciasis-related blindness in Burkina Faso before the OCP began estimated that the country lost 60,000 productive man-years annually.

The intensity of onchocerciasis transmission is highest near rivers and streams where the vector flies breed. Some of the most fertile valleys in tropical Africa have been abandoned because of this disease. Moreover, the presence of simuliid flies and the fear of onchocercal blindness tends to hinder the implementation of large irrigation, dam building and other economic development projects.

## **c. Child survival**

Onchocerciasis is rarely a primary cause of death, particularly among the young, so child survival is not directly affected. However, in hyperendemic areas, it is likely that infants are exposed to the bites of infective black flies from the day of birth. Infection begins in childhood as early as the first year of life. Because of repetitive exposure to this parasitic disease, many children are condemned to a future of misery and the possibility of blindness.

### 3. Control Measures

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#### a. Vector control

The greatest success in onchocerciasis control has been realized with larviciding campaigns to control the vector black flies. The WHO Onchocerciasis Control Programme (OCP) uses weekly aerial spraying of larvicides with low environmental impact in 11 West African countries. When the program began in 1974, it was estimated that 10 percent of those living in the original seven OCP countries had onchocerciasis and about 127,000 were blind. Today, the OCP covers an area of 1.3 million square kilometers, incorporating about 25 million people.

In 1982, the OCP's epidemiological evaluation unit surveyed part of the program area, comprising Burkina Faso, the eastern part of Mali, the northern parts of Ghana, Cote d'Ivoire and Togo, and a small part of western Niger. The analysis confirmed the interruption of onchocerciasis transmission in all the river basins of these areas, except for the Kara basin in Togo. It stated that "the 500,000 children born since the start of vector control operations are free from onchocerciasis and now run no risk of blindness due to *O. volvulus*. Throughout the 650,000 km<sup>2</sup> kilometers covered in this evaluation, onchocerciasis no longer constitutes an obstacle either to the resettlement of populations on the fertile lands, or to the socioeconomic development of the zones concerned."

A 1984 epidemiological evaluation of onchocerciasis in the OCP area focused on infections among children born after the start of the larviciding campaign. The investigators concluded that vector control had been successful in interrupting transmission in 90 percent of the original OCP area (Report of the Tenth Meeting of the Scientific Working Group of Filariasis, Bamako, 1984).

As a result of OCP efforts, some 20 million people are free of the fear of going blind and an estimated 90,000 people have been saved from blindness. Some 15 million hectares of tillable land, sufficient for producing two million tons of sorghum a year, have become available for resettlement.

The sponsoring agencies plan to disband the OCP and transfer responsibility for control operations to participating governments some time during the next decade in a process called "devolution." It seems unlikely, however, that these countries could afford to continue

the expensive larviciding program. The OCP has recommended continuing the campaign at least until 1997.

## **b. Chemotherapy**

The use of filaricidal drugs in mass campaigns has been considered impractical because of the adverse long-term toxic effects of the available compounds. Suramin is an efficient macrofilaricide, but it is difficult to administer and may produce dangerous reactions in heavily infected patients. Diethylcarbama-zine (DEC) is a most efficient microfilaricide, but it has no effect on the adult worm. Its action on microfilariae causes severe, unpleasant side effects.

A newer, semi-synthetic compound, ivermectin, provides longer lasting control of microfilariae with fewer side effects. Trials of the drug have produced promising results with minimal systemic side effects. After a single oral dose of 200  $\mu\text{g}/\text{kg}$ , microfilariae in the skin and eye are reduced for longer periods of time than after multiple doses of DEC. Although the drug appears to have some effect on the release of microfilariae by females, it does not kill adult worms. Retreatment of patients at six- to 18-month intervals is expected to be the ideal regimen in endemic areas where substantial transmission occurs.

Ivermectin is extremely important for blindness prevention, but new data indicate that microfilariae may return to the skin of patients within six months after successful treatment. This casts serious doubt on the hope that ivermectin might be effective in interrupting transmission.

Moreover, continuous ivermectin treatment is not considered safe for pregnant women, women breast-feeding a child younger than three months, children younger than five, people with severe diseases of the heart, liver and kidney, and those at high risk of sleeping sickness or other diseases that might compromise the blood-brain barrier. It is estimated that these exclusions, combined with missed treatments and refusals, would make it possible to treat only 65 percent of microfilariae carriers.

The producers of ivermectin (Mectizan<sup>®</sup>), Merck, Sharp and Dohme, have offered the drug free of charge for use in developing countries. The only stipulations are that it be used in public health programs that can assure appropriate use, monitoring and record-keeping.

### c. Vaccination

The host immune response to *O. volvulus* is thought to play a major role in the pathogenesis of complications. However, there is no clear evidence of protective immunity to reinfection in individuals who continue to be exposed to infective larvae. Antigens of *O. volvulus* are complex and show extensive cross-reactivity with other filarial parasites of humans and animals. Therefore, the prospects for developing a vaccine to protect against onchocerciasis in the near future do not seem very bright.

### d. Nodulesctomy

Since 1933, Guatemala has attempted to control onchocerciasis through a systematic denodulization campaign. Specially trained lay surgeons (brigades) visit each coffee plantation in most endemic areas about every six months to conduct nodulesctomies. Appropriate comparative data are not available, but there is no evidence that the prevalence of the disease has been reduced by this campaign. However, blindness has decreased on the Panajabal Coffee plantation in Yepocapa, Municipality of Chimaltenango. Some experts believe that the campaigns have limited the amount of blindness that might have occurred otherwise.

### e. Constraints to control

#### Technical constraints

Development of more precise diagnostic techniques is essential for an accurate assessment of onchocerciasis prevalence. *O. volvulus* infection is detected by taking two small, bloodless skin snips from the iliac crest of each patient and leaving them in a drop of distilled water for 30 minutes, examining them under a microscope, and counting the number of microfilariae that emerge. This technique produces a high rate of false negatives, even among individuals with onchocercal nodules. Because of the imprecise nature of the skin-snip technique, claims of significant reductions in the prevalence of onchocerciasis in the OCP region may be exaggerated.

OCP's strategy is to control the black flies that transmit *O. volvulus* from one human host to another. Because the

adult worms of *O. volvulus* live for 10 to 15 years or longer and there is no safe drug to kill adult worms (macrofilariicide), it is necessary to continue larviciding for at least 15 years in order to halt transmission. A larviciding campaign that lasts more than 15 years is not only expensive, but it may promote the development of insecticide resistance in the flies.

The OCP has already experienced problems because of the development of resistance to temephos (Abate<sup>R</sup>), the main larvicide used in the OCP, by certain cytospecies of the *S. damnosum* complex. Levels of resistance to temephos 100 times higher than that of susceptible populations and cross-resistance to chlorphoxim and other organophosphate larvicides were observed shortly after the expansion of the program. The OCP has actively screened several potential alternate insecticides to overcome the resistance problem. One solution has been to alternate chlorphoxim in the wet season with the biological control agent *Bacillus thuringiensis* var. *israelensis* (*Bti*) during the dry season in areas where black fly larvae have developed resistance to temephos.

Another threat to the success of the OCP is reinvasion by flies from non-treated stretches of rivers or river basins adjacent to the program area. Studies of the distribution and movements of the different species of the *S. damnosum* complex have revealed that the OCP area is regularly invaded, primarily by savannah species. Many of these invading black flies are infective. The only way to overcome this problem is to treat the source breeding sites of the invading flies by extending the OCP boundaries.

Switching from a black fly control strategy to one that relied solely on ivermectin distribution would allow reinvasion of infective black flies throughout the OCP region. Ivermectin distribution has been considered as an option to larviciding after the OCP's devolution, but recent findings suggest that the drug's effects are too short-lived to control transmission. Establishing an effective distribution system could be as difficult, if not as expensive, as mounting a larviciding campaign.

### **Human resource constraints**

Between 1974 and 1982, a total of 134 people had received training organized by the OCP. Sixty of them were

nationals of the participating countries who received training to work within OCP. The courses were mainly for technical training in medical entomology and parasitology, microscopy and ophthalmology, held at specialized centers of the OCCGE. The program also had arranged for the training of 77 persons employed or about to be employed in their national services, one-third of such training being at the university level.

This level of training is adequate to meet the OCP's current needs, but it has not trained enough people in relevant specialties to meet future needs during devolution. If these needs are to be met, regional or national training programs will have to be developed to ensure a constant supply of operational specialists in each participating country. Each country will probably need about 50 to 100 specialists.

### **Economic constraints**

The OCP is an expensive effort. A.I.D. and other OCP donors already have contributed more than US \$280 million to the program. These donors have made it clear, however, that they plan to transfer the responsibility for maintaining onchocerciasis control to the participating countries some time during this decade.

In 1981, an Independent Commission established to study the long-term future of the OCP recommended that devolution begin in about 1990-95. The current target date for beginning this gradual transfer is 1997. Plans for devolution raise questions about how the OCP countries, some of them among the poorest in the world, will be able to afford the long-term costs of disease control. The Commission concluded that some countries may need help indefinitely.

Ironically, the OCP's success may be a threat to its survival. Onchocerciasis no longer appears to be a public health problem in many OCP areas because of the program's efforts and this makes it more difficult to sustain the interest of donors.

## 4. Current Research

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### a. Diagnosis

Parasitological diagnosis of onchocerciasis depends primarily on the demonstration of microfilariae in the skin. Researchers are working to develop immunological methods to detect *O. volvulus* infection. Ideally, such a test would provide a measure of intensity of infection and allow a species-specific immunodiagnosis of onchocerciasis. A diagnostic test fulfilling all of these criteria would permit chemotherapeutic intervention of infections before symptoms occurred, which would reduce the likelihood of serious adverse reactions. It also would be more convenient and reliable in epidemiological surveys and would provide a more sensitive method for monitoring vector control efforts and drug trials.

### b. Chemotherapy

Recent studies show that a single oral dose of 200  $\mu\text{g}/\text{kg}$  of ivermectin reduces the number of microfilariae in the skin to almost zero. Phase III studies of ivermectin in onchocerciasis were initiated early in 1985 in about 1,200 patients. More than 300,000 people have been treated in subsequent studies. The clinical data confirm the sustained decrease of skin microfilarial loads without serious side effects after a single oral dose of ivermectin. The drug has been field-tested on a large scale in West Africa with excellent, long-lasting microfilaricidal effects and very few adverse side effects on human subjects.

Initial hopes that ivermectin might be useful in reducing transmission have faded because these studies have shown that microfilariae may return to the skin six to eight months after treatment. The drug is considered an excellent tool for treating clinical onchocerciasis and reducing blindness rates.

### c. Vaccine development

The Edna McConnell Clark Foundation Program in Tropical Disease Research supports research on onchocerciasis vaccine development at institutions in the United States, the United Kingdom, West Germany and Australia. The size and successful adaptation of *O. volvulus* almost exclusively to man make it a formidable target for

a vaccine. On the other hand, with the techniques of immunology and molecular biology, scientists continue to make strong advances in understanding the human immune response and defining immunogens responsible for protective immunity. In order to bring these skills to bear on a neglected disease of the developing world, the Foundation has accepted the risk that progress may be slow and difficult.

Investigators are also trying to develop a laboratory animal model for onchocerciasis. Vaccine research in onchocerciasis is severely constrained by the lack of an adequate model.

#### **d. Vector control**

Research on black fly larvicides has been accelerated because of concerns about insecticide resistance in the OCP region. The search for new chemical compounds continues, while other investigations involve efforts to improve biological control agents or discover new strains of larvicide-producing bacteria. Drug manufacturers are doing most of the work on the formulation of biological larvicides, with the OCP and other researchers conducting field tests.

There have been few trials of vector control in Latin America. Mountainous terrain, cloud cover and numerous watercourses obscured by dense vegetation not only preclude the application of larvicides by aircraft, but also contribute to the difficulty of delivering and applying such compounds at ground level. The results of a field trial of larviciding conducted in San Vicente Pacaya, Guatemala, demonstrate some promise, but the investigators emphasized the need for a thorough pretreatment survey to ensure that the innumerable tiny trickles serving as breeding sites of the vector are not missed. Preparing hydrological maps in mountainous terrain of this kind would be a formidable, if not a prohibitive, task.

## 5. Onchocerciasis from the A.I.D. Perspective

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The OCP in West Africa is the most concerted effort to control onchocerciasis ever attempted. A.I.D. is a major contributor, along with other donor nations, to the remarkable success the program has enjoyed thus far.

A.I.D. support for control efforts is considerably less in other areas, particularly in Yemen and most of the Americas. Despite the lack of onchocerciasis-related mortality, continued support for control and research efforts is warranted because of the severe economic effects of this disease.

Onchocerciasis' impact on economic productivity is perhaps the greatest area of concern for A.I.D. and other development agencies. There are few reliable data from which to derive cost-benefit analyses, but anecdotal reports prior to the initiation of OCP stated that between 65 and 80 thousand square kilometers of farmland had been deserted as a result of onchocerciasis. The successful activities of the OCP have permitted a significant reclaiming of that land and there are children younger than 10 who have never seen a black fly.

### a. The Horizon

The OCP is scheduled for completion during the next decade, when donor agencies plan to pass on control efforts to host countries. Although an extensive entomological surveillance and evaluation network is in place in the OCP, it is unlikely that these systems will be maintained without outside support. The main reason for their existence is to support larval control efforts. Considering the massive cost involved in aerial application of larvicides, it is unlikely that this approach will be continued once multi-donor funding has dwindled.

The development of ivermectin provides the potential for treating onchocerciasis. The use of primary health care systems to diagnose the disease, distribute safe drugs or implement other interventions may play a key role in continuing successful control of river blindness. However, conversion from a program of black fly control to one that relies solely on ivermectin would allow black fly reinvasion. In many of the 12 host countries of the OCP, health care delivery systems will have to be improved or created in order to provide ivermectin effectively.

In addition to the promise offered by ivermectin, several other tools that have been developed recently or are in various stages of development will increase the efficacy of control efforts. Precise, rapid identification of different stages of both parasite and vector with DNA probes will help to monitor the success of interventions and better focus future control activities.

#### **b. Priorities for future action**

- Attempts to integrate some aspects of onchocerciasis control into PHC systems by training primary health care workers to organize and prepare villagers for diagnostic procedures in surveillance or evaluation projects and administration of drugs in treatment programs. The primary health care worker also could serve as the first level of contact in the health system referral network to transmit messages to district field workers.
- Operations research to develop cost-effective drug distribution systems.
- KAP studies to provide information that could be used to redesign school health curricula in onchocerciasis-endemic countries and improve other health education efforts.
- Training of cadres of national experts who would be responsible for careful surveillance of human and fly populations in order to monitor and maintain control efforts in OCP countries.
- Research on vector distribution and behavior, new diagnostic tools and improved methods of measuring the intensity of infections.
- Studies to develop additional environmentally safe larvicides and further refine *Bti* formulations.
- Development of field-usable immunodiagnostic tests and improved immunodiagnostics to enable quantification of worm burdens in infected patients.

- Studies to develop and screen new macro- and micro-filaricidal compounds and determine the mode of action and possible chemoprophylactic action of ivermectin and other drugs currently in use.
- Research using the techniques of immunology and molecular biology to develop a vaccine against *O. volvulus*.
- Research on vector biology, including development and testing of DNA probes for use in black fly taxonomy, studies to determine mechanisms of insecticide resistance in black flies and cytotaxonomic studies to describe more precisely and characterize members of the Central and East African members of the *S. damnosum* complex.

## 6. Selected References

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- Anantaphruti, M., Kino, H., and Terada, M., et al. (1982). Studies on chemotherapy of parasitic helminths (XIII). Efficacy of ivermectin on the circulation microfilariae and embryonic development in the female worm of *Dirofilaria immitis*. *Jap. J. Parasitol.*, 31(6): 517-529.
- Awadzi, K., Dadzie, K.Y., and Schulz-Key, H., et al. (1984). Ivermectin in onchocerciasis (letter). *Lancet*, Oct. 20, 2(8408): 921.
- Awadzi, K., et al. (1985). The chemotherapy of onchocerciasis X. An assessment of four single dose treatment regimes of MK-933 (ivermectin) in human onchocerciasis. *Ann. Trop. Med. Parasitol.*, Feb, 79(1): 63-78.
- Aziz, M.A., Diallo, S., and Diop, I.M., et al. (1982). Efficacy and tolerance of ivermectin in human onchocerciasis. *Lancet*, July 24, 2(8291): 171-173.
- Aziz, M.A., Diallo, S., and Lariviere, M., et al. (1982). Ivermectin in onchocerciasis (letter). *Lancet*, Dec. 25, 2(8313): 1456-1457.
- Aziz, M.A. (1986). Ivermectin vs. Onchocerciasis. *Parasitol. Today*, 2(29): 233-235.
- Bissan, Y. and Ranque, P. (1984). Report on the Tenth Meeting of the WHO Scientific Working Group on Filariasis, Bamako, Nov. 5-9.
- Campbell, W.C., Fisher M.H., and Stapley, E., et al. (1983). Ivermectin: A potent new antiparasitic agent. *Science*, Aug. 26, 221(4613): 823-828.
- Campbell, W.C., and Benz, G.W., (1984). Ivermectin: A review of efficacy and safety. *J. Vet Pharmacol. Ther.*, March, 7(1): 1-16.
- Campbell, W.C. (1985). Ivermectin: An Update. *Parasitol. Today*, July, 1: 10-16.
- Coulaud, J.P., Lariviere, M., and Aziz, M.A., et al. (1984). Ivermectin in onchocerciasis (letter). *Lancet*, Sept. 1, 2(8401): 526-527.

- Cupp, E.W., Bernardo, M.J., and Kiszewski, A.E., et al. (1986). The effects of ivermectin on transmission of *Onchocerca volvulus*. *Science*, Feb. 14, 231(4739): 740-742.
- Diallo, S., Aziz, M.A., and Lariviere, M., et al. (1986). A double-blind comparison of the efficacy and safety of ivermectin and diethylcarbamazine in a placebo controlled study of Senegalese patients with onchocerciasis. *Trans R. Soc. Trop. Med. Hyg.*, 80(6): 927-934.
- Glancey, B.M., Lofgren, C.S., and Williams, D.F. (1982). Avermectin B1a: Effects on the ovaries of red imported fire ant queens (Hymenoptera:Formicidae). *J. Med. Entomol.*, Nov. 30, 19(6): 743-747.
- Goodwin, L.G. (1984). Recent advances in research on filariasis. Chemotherapy. *Trans. R. Soc. Trop. Med. Hyg.*, 78 (suppl.) 1-8.
- Green, B.M., Taylor, H.R., and Cupp, E.W., et al. (1985). Comparison of ivermectin and diethylcarbamazine in the treatment of onchocerciasis. *N. Engl. J. Med.*, July 18, 313(3): 133-138.
- Lacey, L.A. and Undeen, A.H. (1986) *Ann. Rev. Entomol.* 31: 265-296.
- Laird. Blackflies. In: *The Future for Biological Methods in Integrated Control*, p. 399. London and New York: Academic Press, 1981.
- Lariviere, M., Vingtain, M.P., and Aziz, M. et al. (1985). Double-blind study of ivermectin and diethylcarbamazine in African onchocerciasis patients with ocular involvement. *Lancet*, July 27, 2(8448): 174-177.
- Lofgren, C.S. and Williams, D.F. (1982). Avermectin B1a: Highly potent inhibitor of reproduction by queens of the red imported fire ant (Hymenoptera:Formicidae). *J. Economic Entomol.*, October, 75(5): 798-803.
- Prescott, N., Prost, A., and Le Berre, R. (1984). The Economics of Blindness Prevention in the Upper Volta under the Onchocerciasis Control Program. *Soc. Sci. Med.*, 19(10): 1051-1055.
- Samba, E.M. (1983). When the horizon brightens. *World Health*, January, 4-5.
- Schulz-Key, Karam, H.M., and Prost, A. (1985). Suramin in the treatment of onchocerciasis: The efficacy of low doses on the parasite in the area with vector control. *Trop. Med Parasitol.*, Dec., 36(4): 244-248.

- Scientific Activities WHO-OMS. (1982). Evaluation of the Onchocerciasis Control Programme. *Bull. WHO*, 60(2): 185-188.
- Terada, M., Ishii, A.I., and Kino, H., et al. (1984). *Angiostrongylus cantonensis*: paralysis due to avermectin B1a and ivermectin. *Exp. Parasitol.*, April, 57(2): 149-157.
- The Onchocerciasis Control Programme. (1983). An Interaction of Politics, Economics, Science and Health. *Interdiscipl. Sci. Rev.* 8(2).
- The Strategy Plan for Onchocerciasis Research. (September 1985). The Edna McConnell Clark Foundation. New York, NY. USA.
- Wang, C.C. and Pong, S.S. (1982). Actions of avermectin B1a and GABA nerves. *Prog. Clin. Biol. Res.*, 97: 373-395.
- World Health Organization (1985). Report of the eleventh meeting of the SWG on filariasis held jointly with the onchocerciasis chemotherapy project. TDR/FIL-SWG(11)85.3.

**Annex 1**

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**Table 1**  
**Status of Onchocerciasis in Selected Countries**

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**Africa**

Kenya	Currently under control.
Malawi	High prevalence and intensity in a relatively small number of communities.
Mali	Major foci in the west, primarily in the Senegal basin -- a target for future action by the OCP.
Niger	Hyperendemic in the Niger River Basin.
Nigeria	Hyperendemic with blindness rates in some villages of nearly six percent. More than half of the onchocerciasis cases in the world are in Nigeria.
Senegal	Hyperendemic with high blindness rates in the east along the Faleme River boundary with Mali.
Sudan	Hyperendemic in three foci along the Bahr el Gazal in the southeast, in the area of Damazin on the Ethiopian border, and in the cataract region of Abu Hamed on the Nile north of Khartoum.
Zaire	Widespread along the eastern borders with Uganda, Rwanda, Burundi and Tanzania.

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**Table 1. (continued)**

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**Latin America**

Guatemala High prevalence in seven of 22 political departments covering 6,000 square kilometers. Prevalence in endemic areas around 10 percent. Low blindness rates.

Ecuador First known focus in the Americas. Distribution is sporadic with an endemic center in the Esmeraldas Province.

**Near East**

Yemen Foci in both North and South Yemen. Onchocerciasis has not been well studied, but it is localized with few reports of blindness.

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