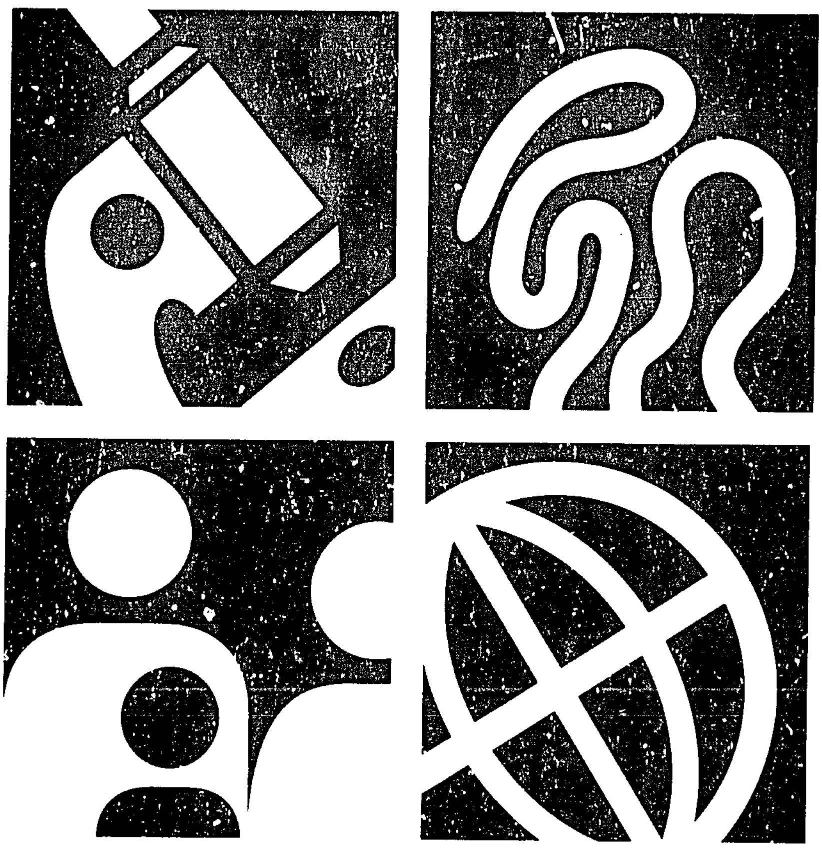
GUINEA WORM DISEASE



VBC TROPICAL DISEASE PAPER NO. 4

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GUINEA WORM DISEASE

(Dracunculiasis)

by

Donald Hopkins, M.D., MPH

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Life cycle illustrations: Taina Litwak
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The blue square shows a Guinea worm. The other symbols depict essential components of vector-borne disease control: the environment, communities and research.

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Executive Summary

Guinea worm disease, or dracunculiasis, affects about 10 millior people in 19 African and Asian countries. It is a devastating, crip pling disease that occurs most often in poor agricultural commun ties in rural or peri-urban areas. There have been few attempts t quantify the effect of Guinea worm disease on economic productivity. However, more than 120 million people are believed to be at risk of infection, which results in periods of incapacitation that may exceed two months. Since these periods often coincide with peak agricultural labor needs, the economic impact is significant.

Humans are the only definitive host for the infection, which con cludes with the emergence of a female worm through a blister on the trunk or lower limbs of the victim. When the infected person tries to relieve the burning pain of the lesion by bathing the affected area, millions of larvae are exuded into the water and infect copepods (water fleas). If this water is also the community' source of drinking water, the copepods infect other people. There are no drugs to treat the disease, secondary infections are commc and the development of the worm, which may reach three feet in length, takes almost a year.

Despite the gloomy picture presented by the infection process, Guinea worm disease is rarely fatal. Measures to prevent it are community-based, inexpensive and extremely effective. In fact, considerable momentum is growing to globally eradicate the disease within the next decade.

The mechanisms that will be used to achieve control include health education, protection of drinking water sources and filterin copepods out of the water or destroying them with heat or chemi cals. Current research efforts focus on improving the impact of these mechanisms in community settings. There is no tropical parasitic disease that has more potential for control or eradicatioı than Guinea worm disease.

1.0 Introduction

Guinea worm disease, or dracunculiasis, is a parasitic disease caused by females of the nematode species *Dracunculus medinensis*. The disease is transmitted to humans when they drink water that contains infected copepods (water fleas), which act as the intermediate hosts for the nematode.

a. Biogeography

Dracunculiasis represents a serious health risk in arid and semi-arid parts of Africa, India and Pakistan (Map 1). The disease is found most often in poor, rural African communities, where prevalence rates of more than 40 percent are common. In India and Pakistan, where various surveillance and control measures are employed, prevalence rates of less than 20 percent are reported. The disease also is reported in Yemen and Saudi Arabia, but the epidemiological data from these areas are insufficient to provide an accurate picture of its prevalence.

b. Parasitic agent

The parasitic nematode *Dracunculus medinensis* causes dracunculiasis in humans. People become infected when they drink water contaminated with infected copepods (water fleas), which are usually found in wells, ponds and other stagnant bodies of water. Infective larvae of the parasite contained within the copepod are released into the human intestine. They migrate to deep subcutaneous tissues, where they mate. The male worms are tiny and play no direct role in disease pathology.

No symptoms occur during a one-year incubation period. Once it has attained maturity, the now lengthy (one-meter-long), mature female worm migrates to a position under the skin, most often in the leg, where she elicits a painful blister. Eventually, the blister bursts, exposing the head of the worm. When the limb is immersed in water, the worm releases thousands of first-stage larvae. If the worm is not extracted, it will continue to expel larvae for some time whenever the affected part of the body comes in contact with water. These larvae may be ingested by copepods and mature to the infectious stage, usually in two to three weeks. They can continue the cycle by infecting the next person who ingests them in drinking water.

There is no animal reservoir of *D. medinensis*. Although related species of *Dracunculus* affect various wild carnivores in some areas, those parasites do not infect humans.

Guinea worm disease is symptomatic only when the female worm emerges through the skin, producing intense burning and irritation. People often immerse the affected limb in water in an effort to reduce the pain and irritation, which in turn stimulates the female worm to release larvae, thus completing the life cycle of the Guinea worm (p. 4). The open ulcer and physical extraction of the parasite usually last from one to three months. Pain and secondary bacterial infection often prevent the patient from standing or walking. In some cases, arthritis, deep abscesses and secondary infections are introduced through the open lesion on the skin. Fatalities are rare, but permanent disability occurs in an estimated one percent of cases.

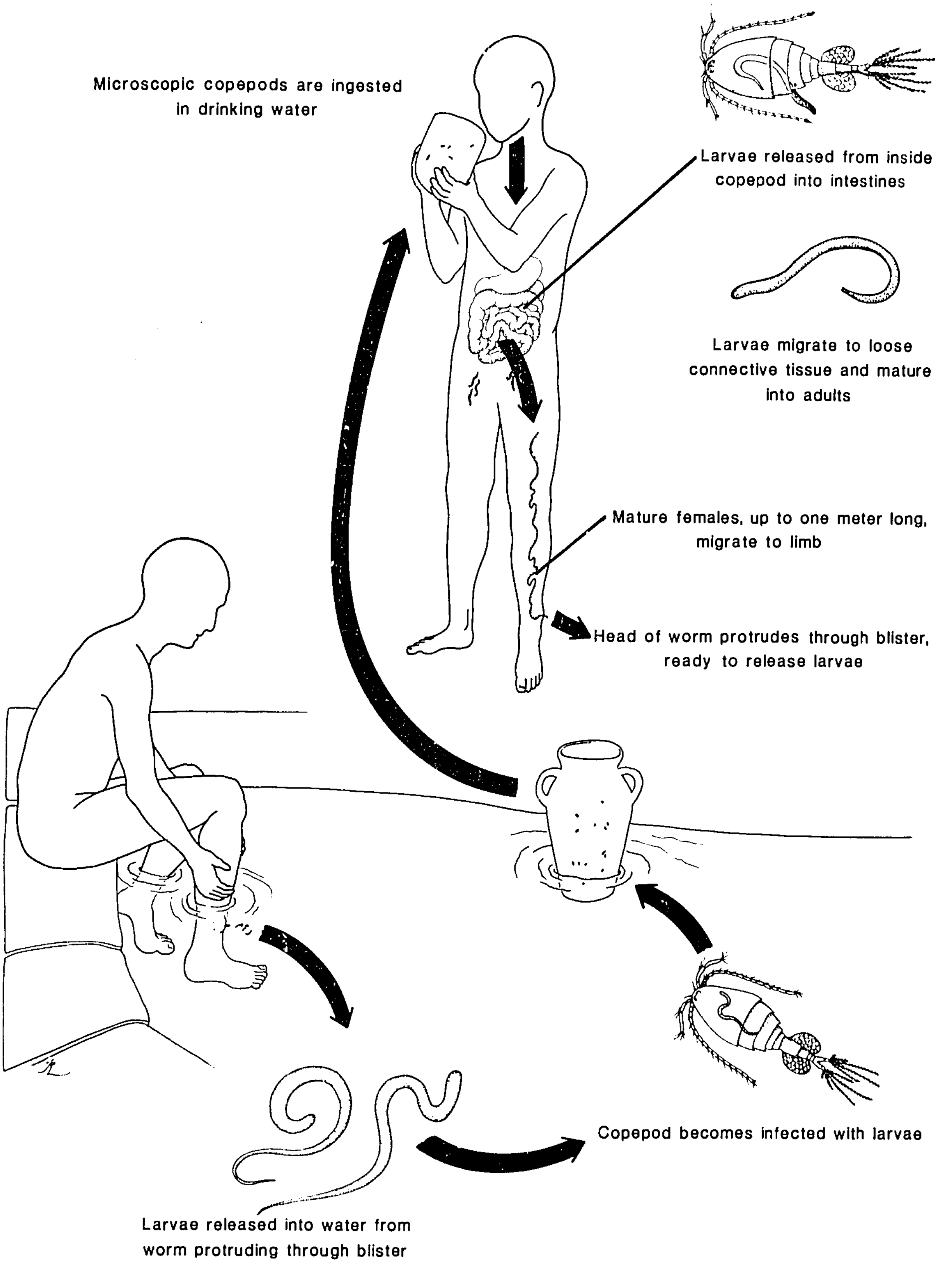
c. Intermediate hosts

The reproductive biology of the cyclopoid copepods is well-adapted to the temporary ponds that are among their most common habitats. Females may reproduce parthenogenetically for many generations, then produce a generation of both males and females before the aquatic habitats dry up. This sexual generation produces fertilized eggs that are resistant to dessication and can remain viable until subsequent rains reestablish the habitat. Such eggs, which are easily transported from place to place by birds, cattle and other animals or by flooding, establish new populations. These new populations remain free of Guinea worm infection until *D. medinensis* larvae are introduced by man.

Unlike mosquitoes, black flies and other blood-sucking insects, the copepod does not actively transmit the infection. Therefore, it is considered an "intermediate host" rather than a "vector."

The copepods that contain the infective, third-stage larvae (about five copepods out of 100 may be infected) tend to sink to the bottom of ponds and step wells. As a result, individuals are more likely to scoop up infected copepods during the dry season when water levels are low. Seasonality is an important aspect of the epidemiology of the disease. Infected copepods are more likely to transmit the disease to man when rivers, streams and ponds form shallow pools or during the rainy season in arid zones, when cyclops populations are at their highest peak.

Life Cycle of Dracunculus medinensis



2.0 Distribution and Severity

Guinea worm disease is believed to afflict an estimated five to 15 million people in Asia and Africa every year. In India, which is one of the only countries in the world conducting active surveillance and employing measures to control dracunculiasis, the disease is reported in six states in the western part of the country, with about half of all the cases occurring in Rajasthan State. The number of endemic villages has declined from 12,840 in 1983 to 5,634 in 1987. An estimate 8.2 million people are at risk of the disease in Pakistan, where the disease is greatly underreported and active surveillance programs had not been conducted until recently. In 1988, a National Guinea Worm Survey detected only 1,111 cases and projected the eradication of dracunculiasis from Pakistan as early as 1990.

One hundred and twenty million people are estimated to be at risk of the disease in 19 African countries: Benin, Burkina Faso, Cameroon, Central African Republic (C.A.R.), Chad, Côte d'Ivoire, Ethiopia, The Gambia, Ghana, Guinea, Kenya, Mali, Mauritania, Niger, Nigeria, Senegal, Sudan, Togo and Uganda.

The most recent information on reported cases of Guinea worm disease submitted to the World Health Organization (WHO) is included in Table 1 in the annex. However, these numbers probably do not provide an accurate picture of the disease's severity because the infection is greatly underreported in Africa. Most infected people live in isolated rural villages and are unable to seek help or medical assistance from clinics or health centers. Active surveillance is not employed consistently.

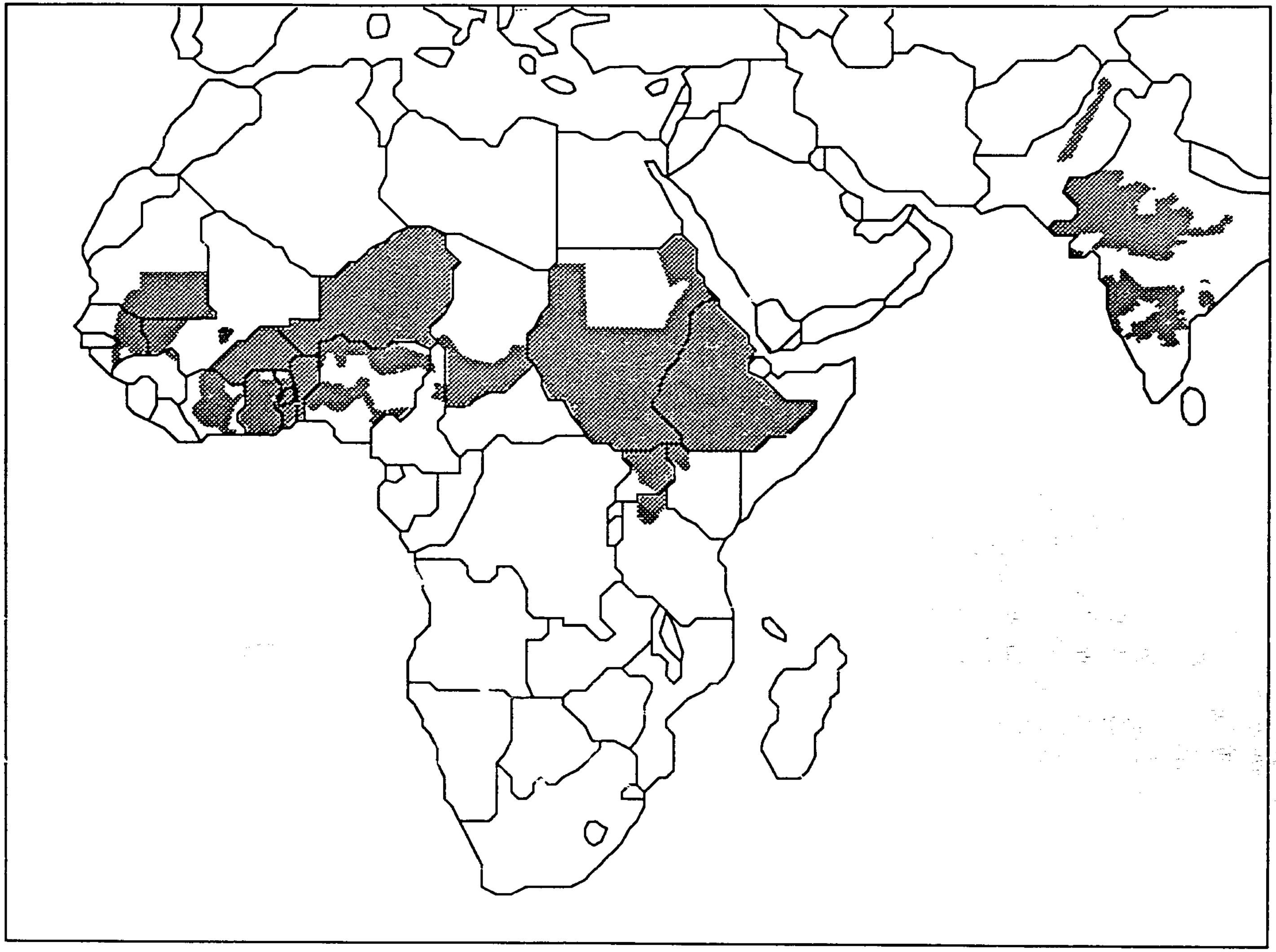
a. Populations affected by dracunculiasis

Dracunculiasis is a disease that affects poor, rural or peri-urban populations that do not have year-round access to safe drinking water supplies.

b. Endemicity

The annual life cycles of the parasite and intermediate hosts foster focal endemicity where poverty and unsafe, open water supplies exist. Movements of people enhance continued introduction of infection into previously clean areas.

Map 1. Distribution of Dracunculiasis



Prepared by the Vector Biology and Control Project
Sources: S. Watts (1987). Am. J. Trop. Med. Hyg. 37(1):119
World Health Organization, 1989

c. Child survival

Although Guinea worm primarily affects adults between the ages of 15 and 44, children are also infected and suffer from temporary disability for weeks or months. Some are permanently disabled or die of tetanus, a complication resulting from secondary infection of the lesion created by the worm. Children also may suffer from indirect adverse effects (Brieger, et. al. 1988, Watts, et. al. 1989). For example, they may experience poor nutrition because infected adult family members are unable to work and provide food for the family. Many children experience a disruption in education while temporarily disabled by the infection or while attending to the needs of affected adults. Reduction in school attendance of up to 25 percent has been reported from communities in Nigeria (Ilegbodu et al. 1986).

d. Economic impact

There have been few attempts to quantify the impact of the infection on economic productivity, but it is thought to be significant because the weeks or months of incapacitation caused by dracunculiasis often occur when the need for agricultural labor is greatest. In 1982, a World Bank economist estimated that global losses in marketable goods as a result of dracunculiasis amounted to between $300 million to $1 billion per year (Golladay 1982). Paul et al. (1986) calculateded that the equivalent of about 5.3 percent of the total agricultural gross domestic product of Burkina Faso was lost because of the effects of Guinea worm disease on local farmers. A UNICEF study in three Nigerian states estimated that eradicating Guinea worm disease in the main rice-growing belt in eastern Nigeria would double agricultural productivity and result in a projected annual increase in rice sale profits of U.S. $20 million (de Rooy 1987).

3.0 Control Measures

a. Treatment

There are no drugs to clear Guinea worms from infected people. The ancient, traditional treatment of slowly winding the emerging worm around a stick until it is completely extracted is still widely practiced in rural villages. This process may take several weeks to complete because the worm resists extraction. If the worm breaks during the extraction process, a severe tissue reaction occurs.

In recent years, treatment with the modern anthelmintics niridazole, metronidazole and thiabendazole has provided symptomatic relief of pain, itching and inflammation. Aspirin also has been used to help relieve local pain, but no drug has proved suitable for effective mass treatment. Because a lethal secondary infection is a possible complication of the disease, tetanus toxoid should be administered to patients with open lesions.

When the female worm is visible beneath the skin before it emerges, a superficial incision can be made that allows removal of the entire worm. However, this procedure has its risks and cannot be done after the ulcer has formed because the emergence of the worm apparently creates an immunologic reaction and the worm resists removal.

b. Control of the intermediate host

The organophosphate pesticide temephos (Abate[R]) kills *Cyclops* and related genera in ponds or step wells used for drinking water. When applied at the recommended concentration of one part per million, this colorless, odorless and essentially tasteless pesticide is safe for human consumption and innocuous to fish and plants. Temephos also has been used to control black fly larvae in the regional campaign against onchocerciasis in West Africa and it is used in potable water for mosquito control in some areas. However, in order to be effective, it must be applied at four- to six-week intervals during the transmission season.

When a group of Indian researchers used temephos in a village of 3,700 persons, a 97 percent reduction in the incidence of dracunculiasis was achieved in one year (Sastry et al. 1978). The manufacturer of temephos, American Cyanamid Company, has donated a quantity of the chemical to the Nigerian State of Anambra's Ministry of Health and to the Government of Cameroon for efforts to reduce Guinea worm disease through *Cyclops* control.

c. Vaccination

There is no vaccine for Guinea worm disease and no research is being conducted to develop one. People do not appear to acquire any natural immunity to the disease and may be repeatedly infected.

d. Environmental sanitation and health education

Prevention is the preferred means of controlling dracunculiasis because the life cycle of the Guinea worm can be attacked at several points. The most suitable long-term preventive measure is the provision of reliable sources of safe drinking water. Initially, providing safe drinking water is relatively expensive, but it is an effective means of control. In addition to reducing the incidence of Guinea worm disease, safe drinking water provides other major benefits, such as a reduction in the time required to gather water and reduced transmission of diarrheal diseases. During the 1930s, piped water was provided to Igbo-ora, a Nigerian town of about 30,000 persons. Within two years, the incidence of dracunculiasis declined from more than 60 percent to 0 (Muller 1971).

Health education is another potentially effective means of control. In villages where transmission occurs, educating villagers who have blisters or emerging worms not to immerse affected limbs in drinking water sources could produce a desirable behavior change that would interrupt the life cycle of the worm. Convincing villagers to boil their drinking water would prevent ingestion of infected copepods, but fuel for boiling water is scarce in some endemic areas.

Infected copepods also may be removed by filtering water through a piece of cloth. Villagers can be taught to use already available cotton cloth for filtering their drinking water, or more efficient and durable filters can be prepared locally, using imported monofilament nylon material at a total cost of $1.50 to $3.00 per filter. An inexpensive, easily cleaned, durable monofilament nylon material suitable for rapidly filtering contaminated water was developed in Burkina Faso (Duke 1984) and is currently being used in a number of community health programs.

A health education program conducted in Nigeria demonstrated how education could drastically reduce transmission of dracunculiasis in endemic villages (Akpovi et al. 1981). Health education flip charts explaining how dracunculiasis can be controlled are available from World Neighbors USA.

e. Constraints to control

Technical

Three control measures are currently used to prevent Guinea worm disease: (1) health education and personal protection; (2) control of the intermediate host using temephos (Abate); and (3) providing safe drinking water. Because the effects of temephos are short-lived and persuading people to change their behavior can be difficult, the most effective and sustainable measure is the provision of safe drinking water. This intervention is technically difficult and expensive, but it provides many other benefits besides eliminating dracunculiasis.

Paul et al. (1986) developed a hypothetical Guinea worm control intervention model to estimate a benefit-cost ratio for the three control methods. Based on this model, providing a community with a safe, protected water supply yielded a benefit-cost ratio of 2.46 (assuming that 40 percent of the costs were chargeable to Guinea worm control and taking into account only the Guinea worm-related benefits). Using this same model, control with temephos had an estimated benefit-cost ratio of 3.89 and providing health education alone had an estimated ratio of 4.68 (Table 2).

Manpower

Drilling boreholes and applying temephos require equipment and trained manpower. Providing information about Guinea worm to villagers is not particularly expensive, but community volunteers and PVO staff must be trained to conduct effective health education efforts.

Economic

Although the cost of Guinea worm control measures may appear substantial, these costs are small compared to the hidden costs exacted by the disease on affected individuals, families and countries. Reducing economic productivity losses caused by

Guinea worm disease would contribute directly to efforts to improve the economies of sub-Saharan African countries. Guinea worm control or elimination could be accomplished with both health and developmental benefits.

Health education

Health education can play a key role in the control of dracunculiasis. Information about Guinea worm disease could be included as part of other health education or agricultural extension services at marginal additional costs. However, superstitions and local beliefs about the origins and causes of Guinea worm disease are deeply rooted and make behavioral change slow and difficult in some areas.

f. Guinea worm disease eradication

Dracunculiasis was systematically eliminated from southern USSR in the 1930s, from Iran in the 1970s, and from several middle-eastern countries in the wake of improved living conditions. In India, the incidence rate of the disease has decreased significantly since a National Guinea Worm Eradication Program was initiated in 1980. This program provided active surveillance and control of the intermediate host, improved the water supply to affected villages and introduced health education to endemic areas. In Côte d'Ivoire and the Republic of Guinea, dracunculiasis' prevalence rates have been reduced dramatically over the past two decades due to aggressive rural water supply programs.

During the Water and Sanitation Decade (1981-1990), Guinea worm disease has become the focus of increasing attention and efforts have been directed toward eradicating it in some areas. These include:

1981 Identification of dracunculiasis as a priority target during the Decade by the Steering Committee of the Decade.

1982 An International Workshop on Opportunities to Control Dracunculiasis.

1985 Designation of the Centers for Disease Control (CDC) as the World Health Organization (WHO) Collaborating Center for Research, Training and Control of Dracunculiasis in Nigeria.

1986 Adoption of a resolution for Dracunculiasis Elimination by the thirty-ninth World Health Assembly.

1986 First Regional Workshop on Dracunculiasis in Africa.

1986 Agreements reached between the Governments of Pakistan and Ghana and Global 2000, Inc., of the Carter Presidential Center in which the latter agreed to help those two countries develop and implement national eradication campaigns.

1980s Adoption of national plans for elimination or control of Guinea worm disease by Benin, Burkina Faso, Cameroon, Côte d'Ivoire, India, Niger, Nigeria, Pakistan, Togo and Uganda.

1988 Second Regional Workshop on Dracunculiasis in Africa, Accra, Ghana.

1989 Adoption of a resolution by the forty-second World Health Assembly in May setting the goal of worldwide elimination of dracunculiasis as a public health problem during the 1990s.

1989 "Target 1995: Global Eradication of Guinea Worm," an international donors' meeting sponsored by Global 2000 and the Bank of Credit and Commerce International in association with UNDP and UNICEF in Lagos, Nigeria.

1990 Third Regional Workshop on Dracunculiasis in Africa, Yamoussoukro, Côte d'Ivoire.

4.0 Current Research

a. Diagnosis

The first clear symptoms of dracunculiasis are generally local itching, urticaria and burning pain at the site of a small blister. Within a few days after the onset of the first signs and symptoms, the blister becomes an ulcer containing a protruding worm. No other infection is likely to be confused with the picture presented by an adult *D. medinensis* emerging through an ulcer. Therefore, developing improved diagnostic tests for Guinea worm disease is not a high priority, but such tests could help reduce transmission by identifying infected people before they become capable of infecting copepods.

A fluorescent antibody test and, more recently, an enzyme-linked immunoabsorbent assay (ELISA) employing crude, adult *D. medinensis* antigens have been used to detect antibodies during the incubation period before infection becomes manifest in humans (Muller 1971; Kliks and Rao 1984). Aiyedun et al. (1985) evaluated skin test, immunodiffusion and hemagglutination techniques using a phosphate-buffered extract of dried adult *D. medinensis* antigen. These tests were not found to be useful diagnostic indicators of infection.

b. Treatment

The ideal drug to treat Guinea worm disease would be lethal to developing worms and would interrupt the transmission cycle. Because of the geographical isolation of most populations exposed to Guinea worm, a suitable drug must be relatively non-toxic, effective against the immature stages of the parasite and administered orally so that a minimum of medical supervision is necessary. Such a drug also must be effective in a minimum number of doses (preferably a single oral dose) because long-term treatment regimens would be prohibitive.

Scientists at CDC have developed a good animal model using the ferret *Mustela putorius* to evaluate the potential effects of selected drugs in treating prepatent larval stages of the infection.

c. Control of the intermediate host

When protection of drinking water sources is not possible, copepods may be eliminated by chemical treatment. Much of the research on controlling copepods, focusing on the efficacy of temephos and the duration of its effect, was completed during the 1970s. Studies in Nigeria (Muller 1970), Ghana (Lyons 1073) and India (Shastry 1978, Sharma 1981 and Rao 1982) showed that temephos could eliminate *Cyclops* populations for five to six weeks. Lyons and Shastry also found that temephos treatment reduced infection rates among people using the treated water.

Methoprene (Altosid™) is a member of a family of chemicals that is known to induce alterations in the development and growth processes of insects. A synthetic juvenile hormone analog, it has been evaluated extensively against mosquitoes and non-target organisms and is sanctioned by the U.S. Environmental Protection Agency and WHO for use as a mosquito larvicide in drinking water sources. The Centers for Disease Control is evaluating Methoprene to determine the susceptibility of various stages of *Cyclops vernalis*.

d. Health education and community prevention

Health education and community prevention are the most promising areas of current research on Guinea worm disease. Dr. T. R. Guiguemde of the Centre Muraz in Burkina Faso has been evaluating the efficacy of health education, water supply and cyclopod control interventions in several villages with support from his government, the OCCGE, USAID (SHDS) and WHO/AFRO. He also has conducted trials to determine the efficacy of monofilament nylon filters for reducing Guinea worm prevalence.

Studies are being conducted at the University of Ibadan, Nigeria, on the efficacy of various health education interventions, including the adoption and use of monofilament nylon filters and on other behavioral research topics. This research receives support from the UNDP/World Bank/WHO Special Program of Research and Training in Tropical Diseases (TDR).

5.0 Dracunculiasis From the A.I.D. Perspective

Nearly all of the countries in which dracunculiasis occurs receive A.I.D. assistance. Although it has not been ranked as a number one health problem by any of these countries, the disease remains a serious localized threat to human productivity and quality of life. Adoption of a resolution for the elimination of Guinea worm disease by the WHO's 1986 World Health Assembly has focused attention on the problem. The resolution has been a significant factor in encouraging improved country reporting and the development of national plans for control and eradication.

Guinea worm is a disease of abject poverty, so the main appeal for its control is humanitarian. As a rural disease, it lacks the visibility of diseases that affect urban populations and receives less attention from epidemiologists and statisticians. Guinea worm disease was not reportable in most countries until recently. Most experts agree that the disease is an impediment to agricultural production, but there have been few efforts to study its impact with sound multisectoral studies.

The only current bilateral A.I.D. program that supports Guinea worm control is in Ghana, where in August 1989 the USAID Mission made available the equivalent of US $2.3 million in local currency to the Ministry of Health for its Guinea worm eradication program. Through its centrally funded WASH and VBC projects, A.I.D has funded a Guinea Worm Information Network that distributes information to more than 500 participants in developing countries. Another recent development is the initiation of a Guinea Worm Eradication Program through the Peace Corps, which began in 1989.

The most likely entry points for assisting Guinea worm control efforts appear to be under the aegis of the community health and water and sanitation programs that are part of the A.I.D. portfolio. Regular meetings between A.I.D., WHO, Global 2000, UNDP, UNICEF and the Peace Corps have developed into a forum for initiating collaborative opportunities to support more effective control.

Since the 1986 World Health Assembly resolution on Guinea Worm Disease Eradication was adopted, considerable momentum for a global eradication effort has been obtained. As a result, a number of African countries have been encouraged to develop national plans for Guinea worm control with eradication as the eventual goal.

The Agency's strong commitment to community-based health care and the tenets of Guinea worm disease control are well-matched because there are few diseases so directly linked to the health of the community and its water supply.

a. The Horizon

The perception of dracunculiasis as a globally eradicable disease is bound to be a hotly debated topic during the next decade. Certainly all indicators point to the elimination of the disease from countries that have given it a high priority, including India and Pakistan. Guinea worm is extremely preventable because it has no other host than man, larvae from an infected person must be introduced into the drinking water supply to perpetuate infection, and ingesting infected copepods from contaminated drinking water is the only way to contract the disease.

The mechanisms for achieving control, such as health education, protection of water supplies and elimination of copepods from drinking water, are simple, inexpensive, extremely effective and appropriate for community-based efforts. The development and implementation of existing technology will have the greatest impact.

b. Priorities for future action

- Building advocacy for dracunculiasis control by demonstrating a clear association between the disease and economic productivity. Through this mechanism, the costs of control can be justified at a national level and those costs can be made part of the development budget, rather than an extra burden on health resources. If political advocacy is to be achieved, it will be on economic, not humanitarian, grounds.

- Developing comprehensive plans to control Guinea worm disease in countries where governments have demonstrated a commitment to control by including financial resources in the national budget.

- Including a Guinea worm control component in designs of future projects in all sectors (health, community development, water and sanitation and agriculture) in endemic areas.

- Encouraging the application of dracunculiasis control technology by other agencies, organizations and PVOs.

- Supporting anthropological studies to identify gaps in knowledge and superstitions about transmission of Guinea worm disease among community members in order to design more effective control measures.

- Supporting operational research efforts to identify the most effective mixture of community-based interventions for specific geographicai areas. These interventions would include health education, filters, water source protection, chemical control of copepods and supportive treatment through primary health care.

- Identifying and promoting the education of voluntary workers who may play an active role in preventing Guinea worm transmission in communities. Particular attention should be paid to the role of women and to the development of simple, effective visual aids and manuals for control personnel and volunteers to use in health education efforts.

- Developing an effective one-dose oral drug to treat people with patent infections and a simple diagnostic test to identify infected individuals before the worms emerge.

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Annex 1. Tables

Table 1. Reported Cases of Dracunculiasis, 1985–1989*

Country	1985	1986	1987	1988	1989
Benin	---	---	400	33962	5692
Burkina Faso	458	2558	1957	1266	5122
Cameroon	168	86	---	752 +	871 +
Ctr'l. African Republic	31	-	1322	---	---
Chad	9	314	---	---	---
Cote d'Ivoire	1889	1177	1272	1370	1555
Ethiopia	1467	3385	2302	751	---
The Gambia	-	-	-	---	---
Ghana	4501	4717	18398	71767	171572
Guinea	-	-	-	---	-
India	30950 +	23070 +	17031 +	12023 +	7881 +
Kenya	---	---	---	---	5 +
Mali	4072	5640	435	564	483
Mauritania	1291	---	227	608	447
Niger	1373	---	699	---	---
Nigeria	5234	2821	216484	653492	622414 +
Pakistan	---	---	2400	1111 +	535 +
Senegal	62	128	132	138	---
Sudan	---	822	399	542	---
Togo	1456	1325	---	178	2749
Uganda	4070	---	---	---	124

*** From passive reporting and/or area-limited searches unless otherwise indicated**
+ National survey
--- No data available
- Zero cases reported

Source: Centers for Disease Control, Guinea Worm Wrap-up #27.

Table 2

Cost-Benefit of Hypothetical Guinea Worm Control Interventions In a Two Year Program Reaching 50,00 People In 100 Villages

Intervention	Cost-Benefit Ratio, no health care available[1]	Cost-Benefit Ratio, health care available[2]	Cost Per Capita, Guinea worm control[3]
Community Water Supply[4]	2.46	2.61	$8.05
Chemical Control (Abate)[4]	3.89	4.14	$3.95
Health Education/ Community Participation Alone[5]	4.68	5.09	$2.82
Health Care Only		0.74	$27.43

Notes:

[1] Health care includes bandaging of lesions and medical care for expected number of secondary infections resulting from Guinea worm infection.

[2] Health care assumed available for 50 percent of the population.

[3] Net present value of program over 10-year horizon divided by target populations of 50,000. Assumed two years implementation cost and eight years running costs; 7.5 percent discount rate.

[4] Community water supply and chemical control interventions also include epidemiological surveillance and health education/community participation components.

[5] Also includes epidemiological surveillance component.

Source: Dr. John Paul. Calculations based on WASH Technical Report No. 38 (September 1986) "Cost Effective Approaches to the Control of Dracunculiasis."

Annex 2. Additional Resources

Several excellent educational films have been developed, including "The Fiery Serpent" and "The Waters of Ayoli," presenting in simple terms the transmission, impact and prevention of the disease. Health education flip charts explaining how dracunculiasis can be controlled are available in English and French for U.S. $4 each from World Neighbors USA, 5116 North Portland Avenue, Oklahoma City, Oklahoma 73112, USA.

The Guinea Worm Information Network, is a joint activity of two A.I.D.-funded projects, the Vector Biology and Control (VBC) Project and the Water and Sanitation for Health (WASH) Project:

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