CHAPTER 7
Cyclops

Intermediate hosts of guinea worm

Cyclops are tiny crustaceans of the family Cyclopidae, also called water fleas. They are usually found in stagnant bodies of fresh water such as wells and ponds in poor agricultural communities in rural or periurban areas. In sub-Saharan Africa, India and Yemen they are the intermediate hosts of guinea worm, *Dracunculus medinensis*, a parasite that causes guinea-worm disease or dracunculiasis. The disease is transmitted to humans when they drink water containing infected cyclops.

Guinea-worm disease is rarely fatal but is severely debilitating. The lower limbs are most commonly affected but the worms, which are up to a metre in length, can emerge from any part of the body. There are no drugs to treat the disease but highly effective and simple preventive measures are available. Most countries where it is endemic have adopted a programme aimed at eradication through such measures as, for instance, supplying safe drinking-water. Several countries have already made dramatic progress: the disease was eliminated from Pakistan in 1996, after seven years of concentrated efforts and in India the number of cases was reduced by more than 99% between 1995 and 1984. Worldwide, the incidence of the disease fell from 3.5 million in 1986 to approximately 122 000 in 1995.

Biology

Cyclops are just visible (0.5–2 mm) and can be recognized by their jerky mode of swimming (Fig. 7.1). They feed on plankton and other small aquatic organisms. Their life cycle is adapted to their natural habitat in ponds and other accumulations of stagnant water. Female cyclops reproduce without fertilization for many generations until the habitat starts drying up. They then produce a generation consisting of both males and females, which produces fertilized eggs. Cyclops can resist drought from one rainy season to the next. Live cyclops have been observed within 30 minutes of a dry pond being filled with water; a day later they had developed into mature females (*1*). The eggs are easily dispersed to other places by animals or floods and can start new populations. The density of cyclops is often highest during the dry season when rivers, streams and ponds form shallow pools. In arid areas highest densities may be reached during the rainy season.

Public health importance

Guinea-worm disease

Because guinea-worm disease occurs only in a limited number of countries and in isolated and poor areas, and because it is rarely fatal, the disease was neglected for many years. Only relatively recently has control of the disease attracted international attention. Before control measures were systematically put in place an

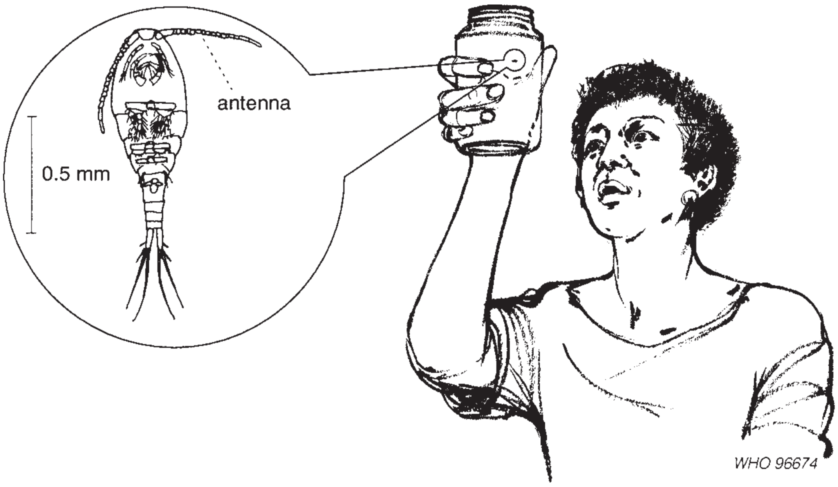

Fig. 7.1
Cyclops can be seen in pond water, collected in a glass jar, as minute dots swimming jerkily. On the left, cyclops as it appears under a microscope.

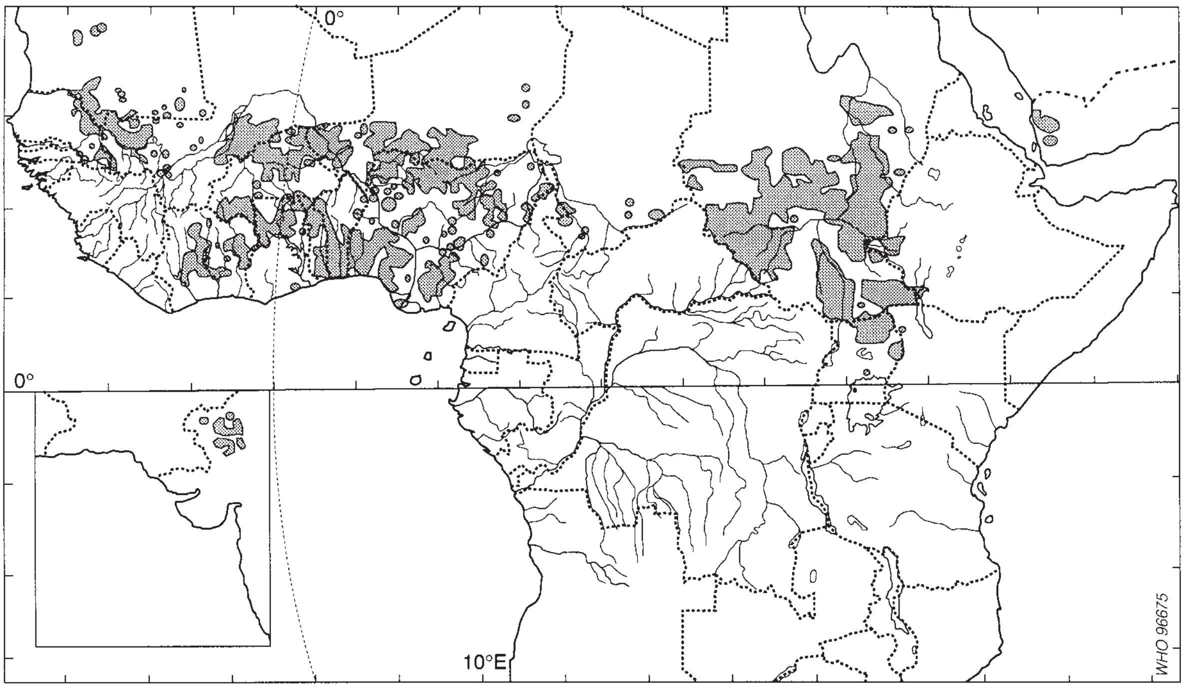

Fig. 7.2
Geographical distribution of guinea-worm disease, 1995. Insert shows the distribution of the disease in India (© WHO).

estimated 10 million people in poor, rural areas in sub-Saharan Africa, India, Pakistan and Yemen were infected. Until the mid-1970s it was also known in the Islamic Republic of Iran and Saudi Arabia. At present the disease mainly occurs in sub-Saharan Africa (Fig. 7.2). In 1994, over 164 000 cases were reported from Africa, one-third of which occurred in Sudan, which only began extending its control and surveillance activities the same year. Outside Africa, the disease has almost disappeared: fewer than 400 cases were reported in India and about 100 cases were reported in Yemen in 1994.

Transmission

Larvae of the guinea worm enter the human body when people drink water contaminated with cyclops containing infective larvae. In the stomach, the cyclops are digested and the larvae can then move around freely. They subsequently try to penetrate the thin intestinal wall. If successful, they end up in the connective tissues of the abdomen and thorax, where they develop into adult worms, mating after three months. When mature, the female moves towards the surface, usually of the legs. About a year after the infection begins the female is ready to emerge from the body to reproduce by releasing up to three million larvae (Figs. 7.3 and 7.4).

In order to emerge, the female produces toxic substances that break down the overlying skin causing painful blisters and ulcers. The worm partly emerges and releases larvae, frequently when the affected person enters water, for example to collect drinking-water. Hundreds of thousands of small larvae are released every time the person enters water over a period of 1–3 weeks. The worm subsequently dies and is eliminated from the body over a period of 3–8 weeks.

The released larvae are not directly infective to humans. They can remain active in water for about three days and die unless they are swallowed by a cyclops. Inside the cyclops, the guinea-worm larvae develop over a period of about two weeks into a larval stage that is infective to humans.

Cyclops infected with guinea-worm larvae also suffer from the infection and tend to sink to the bottom of the water. As a result, people in humid savanna areas in sub-Saharan Africa are most likely to become infected during the dry season when water levels are lowest and they scoop to the bottom of ponds or wells in order to obtain water (Fig. 7.5).

Sites where people are at risk of infection

Guinea worm occurs only in areas where the water temperature is above 19 °C for part of the year. At greatest risk are communities that depend on ponds, cisterns and stepwells for drinking-water.

Sites suitable for transmission are accumulations of water where:

- infected people enter the water;
- the water is stagnant and cyclops species, which can transmit the parasite, are present;
- the water is used regularly as drinking-water.

Typical examples are hand-dug water-holes in West Africa, stepwells in India, pools in dry river beds and temporary accumulations of water in fields in agricultural areas (Figs. 7.6–7.8).

Seasonal fluctuations in transmission

In dry areas in sub-Saharan West Africa and in western India, peak transmission occurs at the onset of the rainy season. Farmers are then planting their crops and

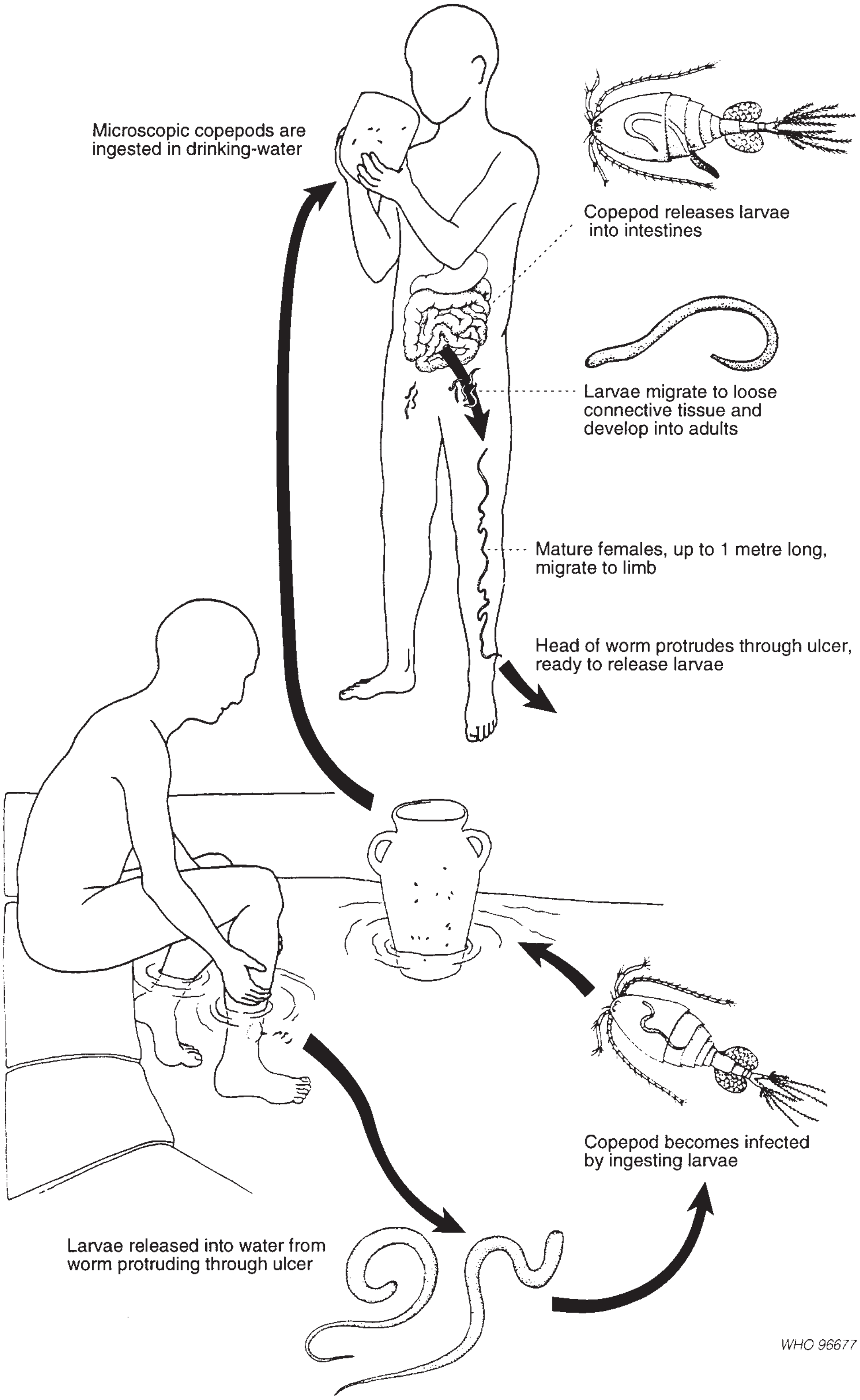

Fig. 7.3
Life cycle of guinea worm (by Taina Litwak for the United States Agency for International Development's VBC Project).

Fig. 7.4
The adult female worm of *Dracunculus medinensis* is white, between 30 and 120 cm long and about 0.2 cm wide (© WHO).

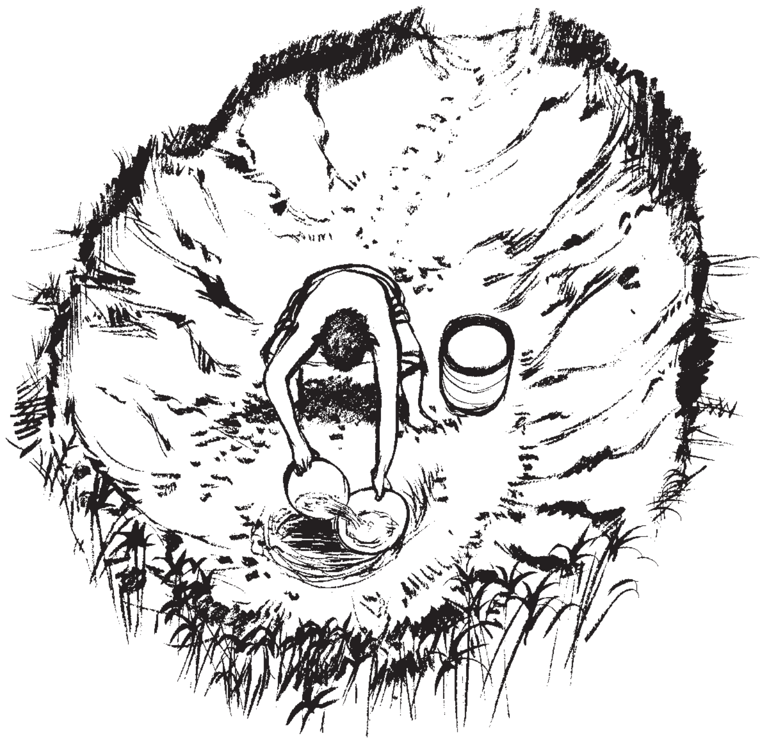

Fig. 7.5
In the dry season when the water level in village ponds drops, the cyclops are concentrated in a small quantity of water and are more likely to be picked up.

drinking-water is collected from rain-filled pools in the fields. Transmission decreases at the end of the rainy season when these ponds dry out.

In the more humid savanna areas of West Africa, transmission occurs mainly during the dry season. In the rainy season there are so many places with surface water that transmission is less likely to occur. In the dry season the drinking-water supply is limited to only a few village ponds where conditions for transmission are more favourable.

Clinical signs and symptoms

The first signs of an infection with dracunculiasis become apparent when the female worm is ready to emerge, about a year after infection. A localized swelling

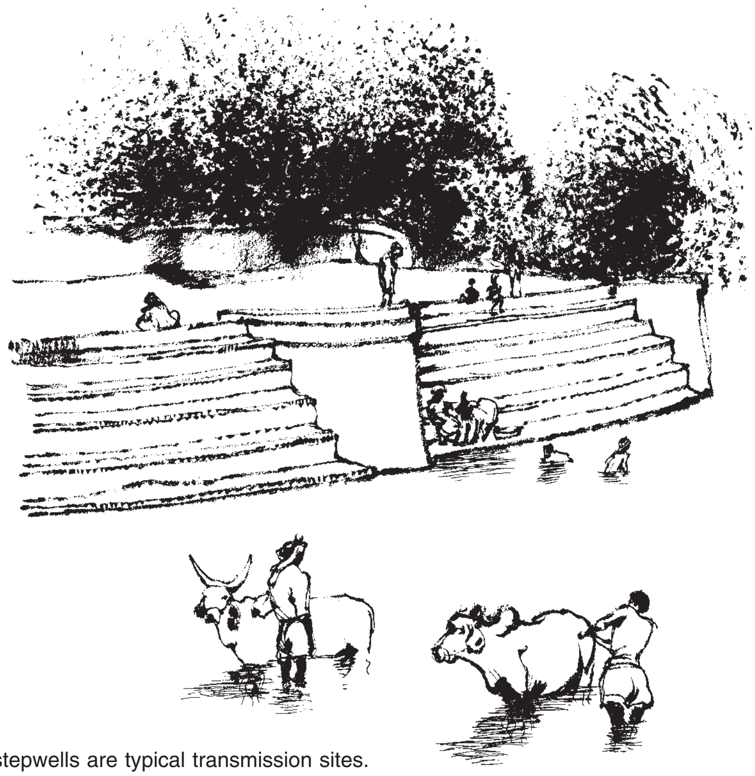

Fig. 7.6
In India, stepwells are typical transmission sites.

Fig. 7.7
Stagnant water pools in a dry river bed are favourable breeding sites for cyclops and may become transmission sites if used as a source of drinking-water.

Fig. 7.8
Small ponds that have been deepened or water holes that have been excavated to collect rainwater are the most important transmission sites of guinea worm in rural Africa.

appears at the spot where the worm will emerge (Fig. 7.9). The swelling itches and a burning sensation is felt. A blister appears a few days later. Accompanying symptoms may be fever, nausea, vomiting and diarrhoea. When the blister is submerged in water the female worm is stimulated to expel larvae. The discharge containing the larvae is sometimes visible as a whitish fluid. The worm lies just below the skin and its hind part protrudes slowly from the blister in order to release all the larvae it contains. This process may take 1–3 weeks, after which the worm dies. Sometimes the worms do not emerge and become calcified. Calcified worms can often be seen and palpated through the skin, and can be detected by X-rays.

The people most affected are those in whom the guinea worm emerges near a joint, for example the knee. Such infections may cause arthritis and permanent crippling. Large abscesses can occur if a worm ruptures and releases larvae into the tissues below the skin.

In about 90% of cases the worms are found in the lower limbs but they can also emerge from the hands, scrotum, breasts, tongue and other parts of the body. Usually only one worm emerges from an infected person but there have been reports of infection with up to 30 worms.

Generally, infections cause much pain and temporary crippling, usually lasting between three weeks and six months; the destruction of joints can cause permanent disability. The emergence of the guinea worm usually coincides with a season when agricultural activities are in progress.

Treatment, prevention and control

There is no natural immunity against guinea worm and no effective drugs or vaccines are available to prevent or treat the disease. The main aim in dealing with infected people is to prevent and treat secondary infections (abscesses, tetanus, septicaemia) and arthritis. The only available treatment is to extract the worm. This has to be done very slowly to prevent the worm from breaking. Only a few centimetres can be pulled out each day. Certain local drugs or medicinal plants are often used to reduce the burning pain in an attempt to facilitate extraction.

A traditional method of preventing the worm from withdrawing inwards is to attach it to a thread tied to the leg (Fig. 7.10). Another commonly used method is to attach the protruding part of the worm to a matchstick, which is twisted round daily until the whole worm has been extracted.

The wound should be cleaned and disinfected daily. A tight bandage should cover it completely to prevent infection of the open ulcer. The bandage also serves as a reminder not to submerge the wound in water and may prevent the release of larvae into water if the wound is submerged. Serious bacterial infections can be treated with antibiotics. Tetanus toxoid should be administered to patients with open ulcers. Severe inflammation is sometimes treated by surgical removal of the worm and pus.

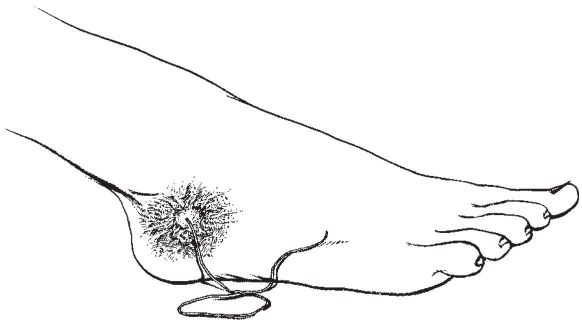

Fig. 7.9
Infection with guinea worm results in an itching and burning swelling on a leg or other part of the body, developing within a few days into a blister and an open sore. The worm emerges at the bottom of the ulcer.

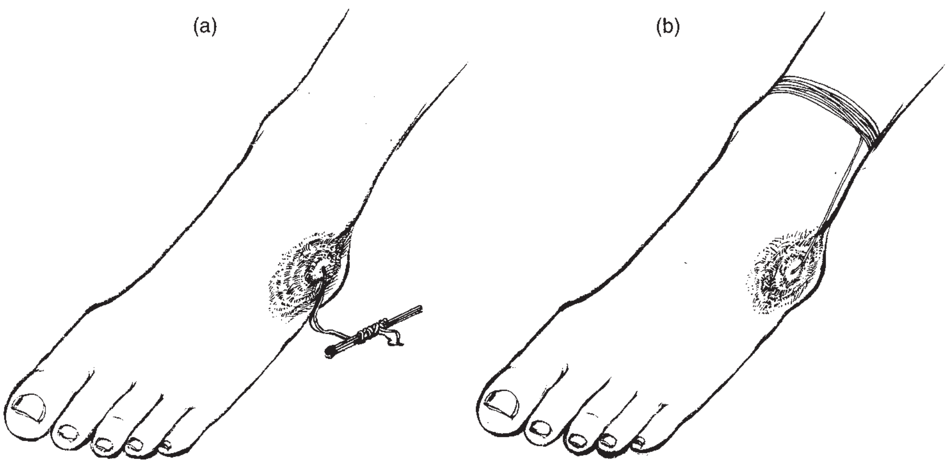

Fig. 7.10
Guinea worms can be extracted slowly by attaching to a string or rolling around a match or small stick to prevent them from withdrawing inwards.

Guinea-worm disease can be controlled by controlling the cyclops in water sources used for drinking, avoiding the swallowing of cyclops and preventing contamination of sources of drinking-water by infected people.

Eradication of guinea-worm disease

Because of the nature of its life cycle the parasite is very vulnerable to small changes in the environment and it is not unrealistic to hope for its total eradication. Simple and cheap measures are available to interrupt transmission. New infections have to be prevented only for a period of a year in order to make the disease disappear completely. The World Health Organization, other international organizations and governments of most countries where the disease is endemic are striving to eradicate it (*2*, *3*). Health education and the organization of eradication programmes based on the active involvement of communities are essential. The support of villagers can readily be obtained because of the unmistakable diagnosis of the infection and its painful and incapacitating effects. Eradication programmes could include, after extensive health education, the training of villagers to dress wounds, provide water filters to community members, and implement simple environmental management measures, such as filling and draining of ponds.

All agricultural and educational projects in areas of endemicity should include the filtering of drinking-water and the keeping of guinea-worm patients out of water while the worms are evident. This should significantly improve the results of the projects in terms of higher food production and better school attendance. Rural water supply projects should give priority to villages where guinea-worm disease is endemic.

Control measures

Effective prevention and control of dracunculiasis requires the education of community members.

Prevention of patient–water contact

People with an emerging guinea worm should never put any part of their body into water used for drinking.

Installation of safe drinking-water supplies

Communities may consider installing bore holes with pumps, piped water systems, or wells with concrete rims to prevent run-off water from draining back in (Fig. 7.11).

Filtration of drinking-water

Filtration is a very practical method, appropriate for use in all areas with guinea-worm disease (Fig. 7.12) (*4–6*). Tightly woven cotton cloth (0.15 mm pore size), available at local markets in all affected areas, can be used to filter all water intended for drinking. However, muddy water quickly clogs such cotton and preference should be given to the use of monofilament filter material. It is impor-

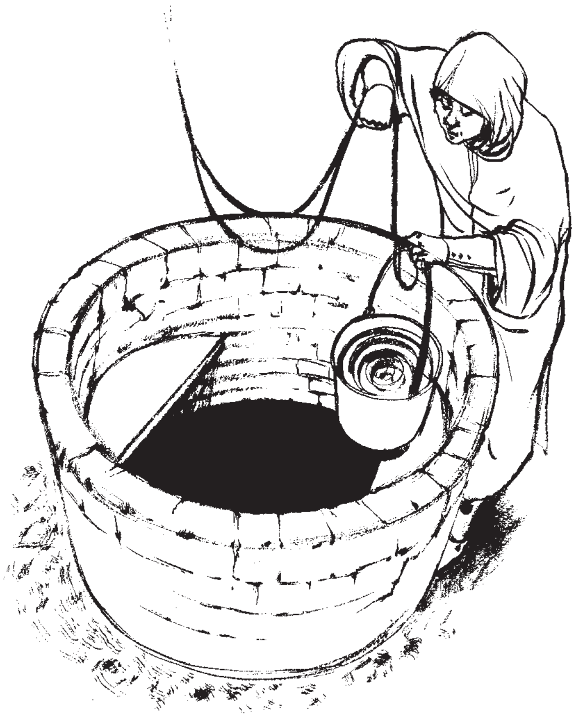

Fig. 7.11
Draw- or pit-well with rim: a safe source of drinking-water.

Fig. 7.12
Cyclops can be removed from drinking-water by pouring it through a gauze filter.

tant always to use the filter material with the same side up, thus preventing cyclops and debris previously caught in the filter from recontaminating the water. Two-layer filters, made of two different colours of cloth, can help ensure this. A logo printed on one side of the filter serves the same purpose.

Suitable filter material

Cotton cloth

Cotton cloth with a mesh size below 0.15 mm holds back all cyclops when infected water is poured through (Fig. 7.13). However, clay particles in the water become trapped in the cotton filaments, quickly clogging the filters and proving difficult to wash out.

Synthetic gauze

Monofilament gauze (bolting cloth) with a mesh size of 0.15 mm is suitable for the filtration of water containing silt (Figs. 7.14 and 7.15). It does not become clogged and is easy to clean.

Chemical control

Cyclops can be killed by treating water sources with temephos, an insecticide that is safe in drinking-water if used at the correct dosage (*7*). This control method is

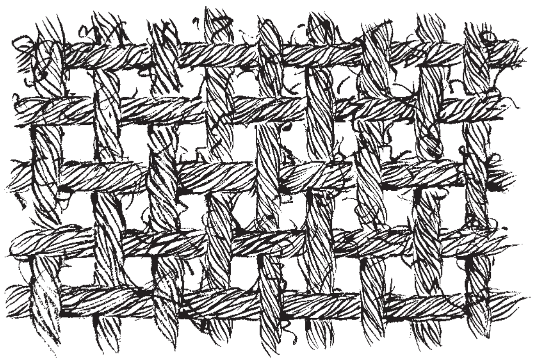

Fig. 7.13
Microscopic view of a sample of cotton cloth. The threads of cotton consist of many small filaments that trap clay particles.

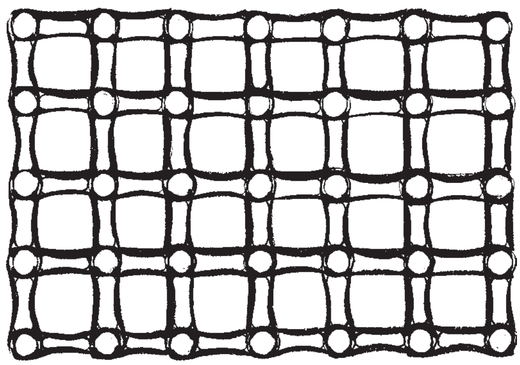

Fig. 7.14
Microscopic view of a sample of monofilament synthetic filter gauze. It does not get clogged up with dirt particles and is easy to wash.

expensive and requires trained personnel to calculate the volume of the water source, mix the chemical at the appropriate dosage, and so forth. It is therefore usually reserved for the treatment of small bodies of water by special eradication programmes.

Application

The most effective formulation in common use is a 50% emulsifiable concentrate, for application at a rate of 2 ml per cubic metre of water. The contents of the pond (in m^3) should be estimated and the correct quantity of temephos mixed in a bucket with sufficient water to distribute the mixture over the entire surface (Fig. 7.16).

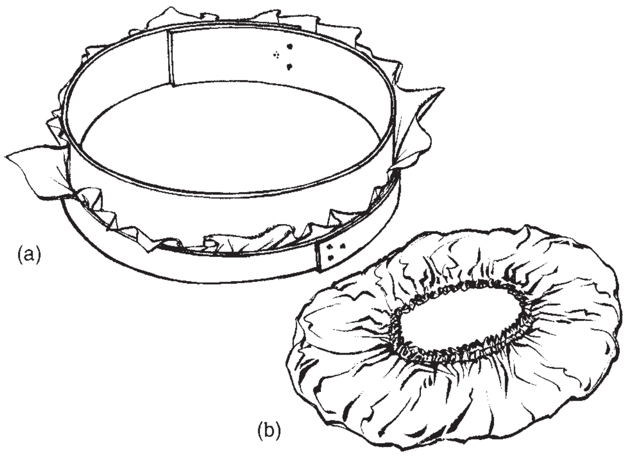

Fig. 7.15
Suitable filter designs: (a) a piece of gauze of about 30 × 30 cm fixed on to a frame made of pliable bark from a local tree; (b) a circular piece of gauze with an elastic band stitched on to the rim; the filter can easily be fitted over the mouth of a water container.

Fig. 7.16
A solution of temephos is thrown over the surface of a pond to control cyclops.

The insecticide should be applied just before or at the onset of the transmission season. It may have to be reapplied every 4–6 weeks throughout the transmission season.

Boiling of drinking-water

Boiling is a simple and effective method for killing cyclops in drinking-water. However, it is time-consuming and requires firewood (which may be scarce) and a fireproof receptacle.

References

1. Chippaux J-P. *La dracunculose en savane arborée au Bénin*. [Dracunculiasis in wooded savanna in Benin.] Paris, University of Paris, 1991 (Doctoral Thesis).

2. Hopkins DR, Ruiz-Tiben E. Dracunculiasis eradication: target 1995. *American journal of tropical medicine and hygiene*, 1990, 43: 296–300.

3. WHA44.5. In: *Handbook of resolutions and decisions of the World Health Assembly and the Executive Board, Volume III, 1985–1992*, 3rd ed. Geneva, World Health Organization, 1993: 109–110.

4. Sullivan JJ, Long EG. Synthetic-fibre filters for preventing dracunculiasis: 100 versus 200 micrometres pore size. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 1988, 82: 465–466.

5. Duke BL. Filtering out the guinea worm. *World health*, 1984, March: 29.

6. Adeniyi JD et al. *Acceptability and use of monofilament nylon filters in a guinea-worm endemic area in western Nigeria: an intervention study*. Geneva, UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases, 1991 (unpublished document TDR/SER/PRS/8; available on request from Special Programme for Research and Training in Tropical Diseases, World Health Organization, 1211 Geneva 27, Switzerland).

7. Sastry SC et al. Abate—its value as a cyclopicide. *Journal of tropical medicine and hygiene*, 1978, 81: 156–158.