Any control program must be a continuing process. Two approaches have proven effective: medical surveillance and treatment, and vector control. (Vector control will be discussed in the next chapter.)

Medical surveillance and treatment aim at the timely detection of cases of trypanosomiasis and a reduction of the parasite reservoir. In endemic *T. gambiense* areas, the appropriate form of surveillance is to have mobile teams screen the population once or twice yearly. This permits the early recognition of a focus that shows signs of becoming reactivated. In endemic *T. rhodesiense* areas, there is little point in screening the population. As this form of the disease is more acute, patients tend to present themselves at medical centres. For this reason and for this form of the disease, it is more appropriate to reinforce primary health care facilities.

Treatment, which requires hospitalization for an average of 30 days, is difficult and not without risk. In some areas where *T. gambiense* is endemic, the drugs suramin or pentamidine have been used prophylactically. These are administered at 6-month intervals, and great care must be taken to make sure that recipients are free from infection.

The available methods of controlling the parasite reservoir and the vectors are far from ideal. Research is in progress to develop diagnostic tests and new and safer drugs.

### 2.7 Onchocerciasis (River Blindness)

#### 2.7.1 Definition

Onchocerciasis (river blindness) is a filarial infection caused by the nematode worm *Onchocerca volvulus*. The parasite is transmitted by several species of blackfly belonging to the genus *Simulium*. The adult worm normally lives in the subcutaneous tissues, where it may be enveloped in a nodule. The microfilarial larvae live in the skin and may be picked up from there by a biting *Simulium*. The main pathogenic effects are to the skin and the eyes.

#### 2.7.2 Distribution

It is estimated that 20 million people are infected with *O. volvulus*. This estimate, however, has remained unchanged since 1947, despite considerable population growth in the affected areas, the availability of better diagnostic methods, and the discovery of new foci. It is therefore reasonable to assume that the actual number of people infected is considerably higher. The great majority of these (99 per cent) live in Africa.

Endemic foci of onchocerciasis exist in tropical Africa, Yemen, Mexico, and Central and South America. In Africa, the northern boundary of endemic onchocerciasis lies between 15° and 19°N, and the southern boundary between 14° and 8°S. One of the largest endemic areas is in the Volta River basin. (See also Volume 2, Annex 1.)

#### 2.7.3 Symptoms

Onchocercal infection in man produces a wide variety of skin changes, nodules, pathol-
ogy of the lymphatics, and some systemic effects. The most dangerous lesions are those of the eye, which may lead to impaired vision and blindness. There are considerable regional differences in the disease, especially in the frequency and severity of particular lesions. The worm-load is an important determinant of the severity of lesions, particularly of the eye.

The most common symptom is itching, which may be localized or may affect the whole body. In long-standing onchocerciasis, the affected skin commonly becomes atrophic and paper-thin. Changes in pigmentation cause patches of lighter-coloured skin ('leopard skin').

The presence of subcutaneous nodules containing a varying number of adult worms is another diagnostic sign. The diameter of these nodules ranges from a few millimetres to some centimetres. They cluster in places where the skin closely overlies the bones. In the forms of the disease that occur in Africa, nodules can be very small and difficult to detect, particularly those on the head. These can be dangerous as they produce abundant microfilariae near the eye.

Living microfilariae can invade all parts of the eye and, living or dead, they can damage the eye structure. Both eyes tend to be affected. Permanent ocular lesions develop only in response to heavier and more prolonged invasion by microfilariae. This level of ocular infection can take years to build up, but it is likely to be reached earlier in the severely afflicted. In West Africa, the risk of blindness is higher in communities in savanna areas than in those in rain forests. There is evidence to suggest that some strains of *O. volvulus* are more pathogenic to the eye than others.

Other, more chronic, consequences of the infection include elephantiasis and hanging groin, sometimes associated with an incapacitating hernia.

Onchocerciasis is a chronic disease that causes serious discomfort and severe incapacitation of its victims. In the conditions prevailing in most parts of Africa, blindness can shorten the victims' life expectancy.

In hyperendemic areas, 5 to 10 per cent of the total population, or even more, may be blind. A closer look at the age and sex of those affected may reveal that 30 to 50 per cent of the adult male population is incapacitated by blindness.

### 2.7.4 Diagnosis

For epidemiological studies, onchocerciasis can be diagnosed in one of two ways. Historically, the common method has been to check for the characteristic nodules produced by adult worms. This method is relatively insensitive because nodules may be absent during the early stages of the infection, or too small or deep-seated to be detected later on. Currently, the most common diagnostic procedure is to examine small, bloodless 'skin snip' biopsies. This is a safe and fast method that causes very little inconvenience to the patient and has proved to be of great value in mass surveys. The microfilariae emerging from the skin snip can easily be recognized under the low power of a microscope, and the microfilarial density (an indicator of the worm-load) can be estimated by counting them.
2.7.5 Life Cycle

The routes followed by the infective larvae after entering the definitive host's skin through a *Simulium*'s bite wound are not known. Immature worms may reach adult size within 2 months of being introduced, but maturation requires 8 to 12 months. Mature worms (males are 2 to 4 cm long, females 30 to 50 cm long) live mainly under the skin, frequently forming visible and palpable nodules that contain one or more coiled-up pairs of worms. It seems that maturing worms can locate each other and congregate. As has been stated, nodules tend to form near bony prominences (hips, chest, scalp). Patients probably have more deep-seated impalpable nodules than palpable subcutaneous nodules.

During its life of up to 15 years, the female worm produces millions of embryos (microfilariae), 150 to 300 microns long. The microfilariae invade the skin, but may also be found in the blood and in various organs. It has been estimated that heavily infected patients may harbour some 50 to 200 million microfilariae at any one time. Microfilariae do not develop in the original host; if they are not ingested by a biting blackfly, they will die after some 30 months (see Figure 2.6).

When a female blackfly bites an infected person, it may take up one or several microfilariae. Within 6 to 13 days, if the temperature is favourable, some of these (15 to 44 per cent of *S. damnosum* in the West African forest, but only 0.3 to 7 per cent in the savanna) will develop into infective larvae in the fly, and will pass through

![Figure 2.6 Life cycle of *Onchocerca volvulus*](image-url)
its head into its proboscis. When the fly feeds again, it deposits these larvae on the skin of its victim, where they may penetrate and create a new host. Flies that ingest microfilariae at their first bloodmeal will be carrying developing larvae when they feed a second time, but they will not usually be infective until the third bloodmeal.

Low temperatures are a limiting factor in transmission. In Tanzania, a critical value, below which transmission does not take place, was found to be 18 °C.

2.7.6 Epidemiology

To compare transmission in different areas or at various seasons, or to evaluate control measures, the 'transmission potential' is used as a parameter. It is defined as the number of infective larvae of *O. volvulus* which are carried by the blackflies that may bite one person during a certain period of time. The transmission potential does not indicate the actual number of larvae transmitted to any one person.

For epidemiological investigations, the Annual Transmission Potential (ATP) is used as a parameter. In the forest zone of West Africa, the ATP's recorded for different places have reached values ranging from 50,000 to 90,000 infective larvae per person. In this bioclimatic zone, however, even the highest figures are not associated with high blindness rates. Paradoxically, in the Sudan-savanna zone of West Africa, ATP values ranging from 500 to 18,000 have been recorded near villages where onchocerciasis prevalence rates in the human population are nearly 100 per cent. There, values above 1500 are associated with a high prevalence of blindness; values of 2500 and above cause such severe blindness problems that whole villages may be deserted.

The level of endemicity is positively associated with the intensity of infection and the occurrence of blindness. Great differences in endemicity are found, even between villages only a few kilometres apart. These differences are directly related to the relative proximity of fast-flowing streams in which the blackfly breeds. Swarms of female flies usually seek the nearest source of animal or human blood.

On the basis of these observations, communities are classified as being first-, second-, or third-line villages. The most striking differences between the three lie in the patterns of disease prevalence by age in children and teenagers, and in the frequency of eye lesions and blindness in adults (Figure 2.7).

In Burkina Faso, levels of endemicity in the Red Volta focus are described as:

- Hyperendemic if the prevalence of infection is 70 per cent or more in first-line villages and the prevalence of blindness is about 10 per cent of the total population. Hyperendemic villages usually have less than 200 inhabitants;
- Mesoendemic if the prevalence of infection is 33 to 66 per cent and the prevalence of blindness is about 5 per cent;
- Hypoendemic if the prevalence of infection is less than 33 per cent and serious ocular problems are rare.

In endemic areas, the general pattern of infection shows an increasing prevalence and severity with age. And while the incidence of infection in males and females is similar, more men than women have nodules and eye damage. These differences may be due to the heavier infections that men incur in the course of their work.

Factors that influence exposure to infection are often related to the cultural, social,
and behavioural characteristics of individuals and groups. Exposure is highest for families who live and work near the banks of the rivers in which the vector breeds. The location of a house may be influenced by the occupation of the head of the household, the traditional pattern of land distribution, and the availability and accessibility of water for domestic use. People whose work brings them into close contact with blackflies include fishermen, ferrymen, workers on coffee plantations, and farmers with holdings near breeding sites.

### 2.7.7 Control

Onchocerciasis, like other vector-borne diseases, can be controlled with campaigns against the parasite, or the vector, or both. Because of the limitations of chemotherapy, however, the mainstay of control is reducing the vector population.

Various features of onchocerciasis control distinguish it from the control of other vector-borne diseases. The control program in Western Kenya, for instance, which succeeded in eradicating *S. naevi*, showed that the cumulative life span of adult *O. volvulus* and its microfilariae is 16 to 18 years. It follows that, in the absence of effective chemotherapy, control efforts will have to be continued over a period of about 20 years to achieve permanent results.

A second feature is the extraordinary ability of *S. damnosum*, in particular, to disperse over long distances. As a consequence, control efforts must cover large areas
to avoid re-invasion from adjacent foci. Of special concern in this respect is the question whether the parasite-vector complexes of the forest are able to colonize the savanna.

Finally, control of *Simulium* may require unusual physical efforts, as in the case of WHO's Ochocerciasis Control Programme against *S. damnosum* in the Volta Basin. *S. damnosum* breeds in large and medium-sized rivers and streams that provide suitable conditions. Numerous breeding sites, spread over an entire river basin, must be reached and dosed every 7 days, which gives rise to problems that may be insuperable without facilities for spraying from the air.

Drugs are available to control the parasite. Nevertheless, suramin, which kills the adult worms, is unsuitable for use in mass campaigns because of its toxicity, and diethyl-carbamazine is only effective against the microfilarial larvae. A new drug (Ivermectine) has proven extremely effective against the microfilaria: a single tablet kills virtually all the larvae in the body, and it needs to be taken only once a year. The drug could offer a fast, cheap method of controlling the disease. The challenge now is making sure it reaches the people who need it (TRD 1988).

As an alternative to drug therapy, the surgical removal of nodules is being practised in Guatemala, both curatively and prophylactically.

### 2.8 Other Fly-Borne Diseases

#### 2.8.1 Leishmaniasis (Kala Azar, Espundia, Oriental Sore)

In both the Old and the New World, sandflies of the genera *Phlebotomus*, *Lutzomiya*, and *Sergentomiya* are vectors of leishmanial infections. Although some species of sandflies, especially of the genus *Phlebotomus*, occur in semi-arid areas, the actual larval habitat must have a high degree of humidity. Eggs are deposited in small cracks and holes in the ground, in the ventilation shafts of termite mounds, in cracks of mud walls and masonry, and in other places that provide the required shelter and humidity. Sandflies that transmit the disease to man have become infected either by man or—more usually—by animals. In most infected areas, the disease is a zoonosis (the reservoirs are dogs and other mammals, or sylvatic rodents), and man is an occasional host.

Three groups of leishmanial infections that affect man are generally recognized. They differ in localization and clinical pattern, in the role of certain species of sandflies as vectors, and in geographical distribution. The infections are:

- Visceral leishmaniasis (kala azar), which is endemic in East Africa, the Indian Subcontinent, and Latin America. It occurs sporadically in China, the Mediterranean Basin, Southwest Asia, and the southern parts of the Soviet Union. The parasite, *Leishmania donovani*, invades the internal organs (spleen, liver) and bone marrow. The disease is usually lethal if left untreated;
- Mucocutaneous leishmaniasis (espundia), which is found primarily in South America, but cases have been reported from Africa (Sudan, Ethiopia). The parasite, *Leishmania braziliensis*, invades the skin and mucosal tissues. The disease begins with a primary skin lesion, followed several years later by other lesions in the mouth, nose, or pharynx. These destructive mucocutaneous lesions carry a social stigma;
Cutaneous leishmaniasis (oriental sore), the most prevalent form, which is found in Africa, Latin America, the Indian Subcontinent, Southwest Asia, the Mediterranean Basin, and parts of the Soviet Union. The parasite, *L. tropica*, invades the skin, causing ulcers that are slow to heal. Uncomplicated ulcers heal within 9 to 24 months. Non-healing lesions occur as diffuse cutaneous leishmaniasis. Even if uncomplicated, the disease leads to high morbidity, a disfiguring lesion, and permanent scarring. In new development projects in forest and desert areas, loss of work time because of the disease can have significant economic consequences.

Sandflies are highly susceptible to insecticides. No resistance problems have yet been reported. Control programs that rely on insecticides and are directed primarily against malaria vectors have been very effective against leishmanial infections. This is illustrated by the epidemic of kala azar that broke out in 1977 in Bihar State, India, after the insecticidal malaria control program had ceased.

2.8.2 Loiasis

Loiasis is a filarial disease caused by the Loa Loa worm. It is transmitted from man to man by mangrove flies (*Chrysops* spp.). These tabanid flies inhabit woods and forests, and breed in low-lying swampy places. The disease occurs in West and Central Africa. The life cycle of the Loa Loa worm resembles that of *O. volvulus*. In man, the adult worms live under the skin, but the microfilariae are found in the peripheral blood.

2.9 Miscellaneous Diseases

2.9.1 Dracontiasis (Guinea Worm)

Guinea worm infection has great social and economic consequences where it occurs: in West, Central, and East Africa (Sahelian Zone), the Eastern Mediterranean countries, the Arabian Peninsula, Iran, Pakistan, and the Indian Subcontinent. The parasite is the filarial worm *Dracunculus medinensis* (length 30 to 120 cm), which inhabits the subcutaneous tissues of its human host. The mature female guinea worm produces a localized sore in the skin of the host, through which it expels numerous microfilarial larvae when the host comes into contact with water. Once water-borne, the microfilariae infect a microscopic, intermediate crustacean host (cyclops or water flea). Man becomes infected by drinking water that contains these infected cyclops.

Dracontiasis sores are painful and often give rise to abscesses, or they involve joints. Not a killing disease, except when tetanus causes complications, dracontiasis can be severely incapacitating for a prolonged period. In West Africa, the average is 100 days per case. Most of the incapacity occurs during the farming seasons, and annual re-infections are not uncommon.

The transmission of guinea-worm infection can be totally stopped by the provision of safe drinking water. Effective control of the disease is therefore based on improving drinking water supplies (i.e. protecting them from contamination).
2.9.2 American Trypanosomiasis (Chagas’ Disease)

The distribution of American trypanosomiasis, or Chagas’ disease, is confined to the tropical and subtropical countries of Latin America. The infection is caused by Trypanosoma cruzi, a protozoan parasite transmitted to man by reduviid bugs (Triatomine spp.), which are also referred to as kissing bugs because of their habit of biting the faces of their sleeping victims.

Many species of this bug, with different habits, can transmit the organism to man and animal alike. The infection is essentially a zoonosis. There are two independent cycles of parasite transmission: a persistent sylvatic cycle in numerous wild animals (e.g. armadillos, opossums, rodents, bats), and an intradomiciliary and/or peridomestic cycle in man and domestic animals.

The parasite can also be transmitted by blood transfusions from infected donors. This is becoming more of a problem because of the increasing migration of infected people from rural areas to urban centres.

The triatomine vectors breed near their hosts in the cracks and crevices of walls, floors, ceilings, and furniture. They especially favour old dilapidated mud-walled and thatched-roofed houses in rural areas or urban slums. In the sylvatic cycle, they breed in rodent burrows and a variety of peridomestic shelters that are used by their avian and mammalian hosts. Immature and adult bugs of both sexes feed on their hosts at night, and may acquire the infection from them. Ingested parasites develop in the gut of the bug. Within 6 to 15 days, the bug begins to excrete infective intermediate forms of T. cruzi while feeding. Man becomes infected by scratching the excreta into the site of the bug’s bite or into skin abrasions.

Once the infective forms have entered the new host, they multiply near the site of penetration. In about 5 days, hundreds of new parasites are released and spread through tissue fluids and blood to various organs. The disease has two stages: acute (occurring shortly after the initial infection) and chronic (in which the heart, esophagus, lower intestines, and peripheral nervous system are affected). As many as 15 to 20 years may elapse between the stages, during which time the infection is present without causing overt illness. The disease is a cause of serious chronic morbidity and disability, as well as mortality.

Spraying houses with residual insecticides has been used to control the infection. This method, however, does not kill bugs resting in natural outdoor shelters. Similar spraying of houses during malaria control campaigns has frequently reduced triatomine populations and, hence, the incidence of Chagas’ disease. More lasting effects, however, can be achieved if housing is improved. Replacing mud-walled houses with those built of brick or cement blocks, and thatched roofs with corrugated metal roofs, will contribute significantly towards the elimination of domestic bugs.

2.9.3 Plague

Plague, or Black Death, has a wide distribution. Until the recent past, it broke out in disastrous world-wide epidemics. At present, small outbreaks occur from year to year. The causative agent is the bacteria Pasteurella (Yersinia) pestis. The disease is essentially a zoonosis of a wide variety of sylvatic rodents. In the urban cycle, domestic
rats (*Rattus norvegicus, Rattus rattus*) form the reservoir of the infection. Various fleas are responsible for transmitting the infection among animals and, occasionally, to man. The most common disease vector is the rat-flea *Xenopsylla cheopis*. The control of plague is based on rodent and rat control, with the careful use of rodenticides and insecticides.

2.9.4 Louse-Borne Fevers

Louse-borne epidemic typhus has appeared on all continents except Australia. It is prevalent chiefly in cooler areas, including the higher altitudes of tropical zones, where heavier clothing is worn. The disease is caused by *Rickettsia prowazeki*. Transmission is from man to body louse to man. Man is considered the reservoir of the infection.

Louse-borne epidemic relapsing fever occurs under the same conditions as epidemic typhus, and the two diseases may appear together. The causative agent is *Borrelia (Treponema) recurrentis*, a spirochete. Transmission is effected by body lice; man is the reservoir of infection.

Control hinges on improving hygienic practices and the availability of water. In epidemic situations, however, such measures can be impractical because immediate re-infestation can occur. In these situations, insecticides (DDT dust) are employed to reduce the louse population.

2.9.5 Tick-Borne Fevers

Tick-borne relapsing fever occurs throughout the tropics, the subtropics, and in some temperate regions. The causative agent is the spirochete *Borrelia (Treponema) duttoni*. Man becomes infected through the bite of an immature or adult soft tick (*Ornithodoros spp.*). Besides man, various animals (mainly rodents) can be the reservoir of infection. The vector breeds in the cracks and crevices of walls, floors, and furniture, in rodent holes, and in the nests of animals and birds.

Control depends on improved housing (of bricks, cement, corrugated iron) and the careful use of insecticides.

2.9.6 Mite-Borne Fevers

Scrub typhus, or Tsutsugamushi disease, is widely distributed throughout Eastern and Southern Asia and on the islands of the South Pacific. Most reported cases are from low-lying areas, but infections can appear at altitudes of up to 1000 m. The causative agent, *Rickettsia tsutsugamushi*, is transmitted by trombiculid mites. People are bitten by the vector mites while visiting or working in areas with so-called ‘mite islands’ (i.e. patches of vegetation that harbour large numbers of immature host-seeking mites). Control is difficult.
References (For further reading see the following references)

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